



**MODULAR POWER SUPPLIES
A, C, AND E SERIES
MODELS 62003A-62048A,
62003C-62048C, AND 62003E-62048E**

**OPERATING AND SERVICE MANUAL
FOR SERIALS 1210A-00101 AND ABOVE***

***For Serials Above 1210A-00101, a change page may be included.**

Hewlett-Packard

SECTION I GENERAL INFORMATION

1-1 DESCRIPTION

1-2 Hewlett-Packard modular power supplies are completely solid-state, employing high-reliability transistors and integrated circuits. The power supplies are packaged in three uniform height and depth cases that are fractions of the standard 19-inch rack width. The supplies can be bench-operated or rack-mounted individually or in any combination to full rack width or less. The modular power supplies are of the Constant Voltage/Current Limiting type, furnishing full-rated output voltage at the maximum rated output current. The output voltage can be adjusted between ± 0.5 V or $\pm 5\%$ (whichever is greater) of nominal while providing full-rated output current. The supply and load are fully protected from current overloads by a self-restoring current cutback circuit that causes the output current to cutback linearly from approximately 103% to approximately 10% of rated output as the load varies from slightly above the maximum rated value to a complete short circuit. The current limit (cutback) activation point is adjustable anywhere between the 103% and 10% limits.

1-3 Either the positive or negative output terminal may be grounded at the rear terminals.

1-4 SCOPE

1-5 This manual provides installation procedures, operating instructions, principles of operation, maintenance data, and replaceable parts information for the thirty-three Hewlett-Packard modular power supplies listed in the following chart. Note that the last two digits in the model number indicate the nominal output voltage of the supply. The —A suffix supplies are 1/8-rack width units while the —C and —E models are 1/4-rack width units.

1-6 SCHEMATICS

1-7 The modular power supplies covered in this manual are of similar design differing mainly in component values rather than in circuit operation. Hence,

in general, the information presented in the manual applies to all of the power supply models with any significant differences among the supplies described as applicable. Thus, the schematic diagrams at the rear of the manual depict groups of similar supplies with five

| DC OUTPUT | | MODEL |
|--|--------------------|--------|
| NOMINAL VOLTAGE (Minimum Adj. Span) | CURRENT AT 50°C | |
| 3V (± 0.5 V) | 2A | 62003A |
| | 4.25A | 62003C |
| | 8.5A | 62003E |
| 4V (± 0.5 V) | 2A | 62004A |
| | 4A | 62004C |
| | 8A | 62004E |
| 5V (± 0.5 V) | 2A | 62005A |
| | 4A | 62005C |
| | 8A | 62005E |
| 6V (± 0.5 V) | 1.75A | 62006A |
| | 3.75A | 62006C |
| | 7.5A | 62006E |
| 10V (± 0.5 V) | 1.5A | 62010A |
| | 3.25A | 62010C |
| | 6.5A | 62010E |
| 12V (± 0.60 V) | 1.5A | 62012A |
| | 3.0A | 62012C |
| | 6.0A | 62012E |
| 15V (± 0.75 V) | 1.25A | 62015A |
| | 2.5A | 62015C |
| | 5.0A | 62015E |
| 18V (± 0.90 V) | 1.0A | 62018A |
| | 2.25A | 62018C |
| | 4.5A | 62018E |
| 24V (± 1.20 V) | .75A | 62024A |
| | 1.75A | 62024C |
| | 3.75A | 62024E |
| 28V (± 1.40 V) | .7A | 62028A |
| | 1.6A | 62028C |
| | 3.25A | 62028E |
| 48V (± 2.40 V) | .45A | 62048A |
| | 1.0A | 62048C |
| | 2.0A | 62048E |

schematics provided to illustrate all 33 models. Each schematic, of course, identifies the supplies for which it applies and includes notes and tables to identify the difference (mainly in component values) among the supplies illustrated in the common schematic.

1-8 SPECIFICATIONS

1-9 Detailed specifications for the power supplies are given in Table 1-1.

Table 1-1. Specifications

| | |
|---|---|
| <p>INPUT: 115Vac $\pm 10\%$, single phase, 48-63 Hz. See Options 101, 102, and 103.</p> <p>OUTPUT: See Paragraph 1-5.</p> <p>LOAD REGULATION: Less than 0.01% or 1 mV whichever is greater for a full load to no load change in output current.</p> <p>LINE REGULATION: Less than 0.01% or 1 mV whichever is greater for a 10% change in the specified input voltage.</p> <p>RIPPLE AND NOISE: Less than 1 mV rms and 2 mV p-p (up to 20 MHz).</p> <p>TEMPERATURE RANGES: Operating: 0 to 50°C ambient. Output current derated linearly for temperatures greater than 50° with 50% of maximum output current at 71°C ambient. Storage: -55°C to +85°C Cooling: Convection cooled.</p> <p>TEMPERATURE COEFFICIENT: Less than 0.01% output voltage change per degree Centigrade over the operating range from 0 to 50°C after 30 minutes warmup.</p> <p>THERMAL PROTECTION: Heat sink mounted thermostat opens ac line if supply overheats due to high ambient temperature. Thermostat automatically closes (reset) when temperature cools to safe operating level.</p> <p>STABILITY: Less than 0.1% total drift for 8 hours after an initial warm-up time of 30 minutes at constant ambient, constant line voltage, and constant load.</p> <p>TRANSIENT RECOVERY TIME: Less than 50 μsec for output recovery to within 15 mV of nominal output voltage following a load change from full to half load (or vice versa).</p> | <p>OVERLOAD PROTECTION: A current limit circuit cuts back current linearly to approximately 10% of rated output current when supply is short-circuited. Automatically resets when overload removed. Current limit activation point adjustable (screwdriver control) but preset at factory to activate at 104 $\pm 1\%$ of maximum rated output current at nominal output voltage.</p> <p>OUTPUT CONTROL: Screwdriver adjustment accessible through hole in front panel. Minimum adjustment range is ± 0.5 V or $\pm 5\%$, whichever is greater.</p> <p>ERROR SENSING: Error sensing normally accomplished locally at rear terminals. Provision included at rear terminal strip for remote sensing with correction for load lead voltage drops of up to 0.5 V total. Load protected if sensing terminals inadvertently opened.</p> <p>MOUNTING: Three mounting surfaces provided for mounting in the upright position. For mounting orientations other than upright, adequate cooling is required. See Section II.</p> <p>DIMENSIONS: A— suffix models: 1.91" W x 5.03" H x 12.25" D (48 mm W x 128mm H x 311mm D) C— & E— suffix models: 3.94" W x 5.03" H 12.25" D (100 mm W x 128mm H x 311mm D)</p> <p>WEIGHT (net/shipping): A— suffix Models: 6 lbs (2, 7 kg)/8 lbs (3, 6 kg) C— suffix Models: 10 lbs (4, 5 kg)/12 lbs (5, 4 kg) E— suffix Models: 13 lbs (5, 9 kg)/16 lbs (7, 3 kg)</p> |
|---|---|

1-11 Options are factory modifications of a standard instrument that are requested by the customer. The following options are available for the instruments covered by this manual. Where necessary, detailed coverage of the options are included in the manual.

OPTION NO.

DESCRIPTION

011

Overvoltage Protection "Crowbar": A completely separate circuit for protecting delicate loads against power supply failure or operator error. The crowbar circuit monitors the output voltage and within 10 μ sec imposes a virtual short-circuit (conducting SCR or triac) across the power supply output if the preset overvoltage margin is exceeded. The crowbar circuit is contained on a printed wiring board that is mounted inside the power supply. The activation (trip) voltage of the crowbar is adjustable (screwdriver adjustment) over the following minimum range: from +0.5 Vdc above minimum rated output voltage to +2 Vdc above maximum rated output voltage.

101

220 Vac, single phase input: Supply is normally shipped with a 120 Vac (nominal) transformer. Option 101 replaces this transformer with a 220 Vac (nominal) transformer and allows operation from a 190-233 Vac, 48-63 Hz single phase input.

102

240 Vac, single phase input: Supply is normally shipped with a 120 Vac (nominal) transformer. Option 102 replaces this transformer with a 240 Vac (nominal) transformer and allows operation from a 208-254 Vac, 48-63 Hz, single phase input.

120 Vac/240 Vac, single phase input: Supply is normally shipped with a 120 Vac (nominal) transformer. Option 103 replaces this transformer with a 120 Vac/240 Vac (nominal) multi-tap transformer and allows field-changeable operation from 104-127 Vac or 208-254 Vac, 48-63 Hz single phase input.

104

System Control: This option allows the user to control the supply's overvoltage protection "crowbar" circuit as well as output voltage. The 104 option includes the same internal, adjustable overvoltage protection crowbar as provided with the 011 option. In addition, the 104 option crowbar includes external (from a rear terminal strip) pulse control capability that allows the crowbar to be either externally triggered or which provides an output pulse to indicate that the crowbar has triggered. The crowbar pulse specifications are:

Input Trigger Pulse:

Voltage: 8 — 15 V

Width (between 90% point at leading edge and 10% point at falling edge): 5 μ sec — 2 msec

Output Pulse:

Voltage: 2 — 12 V

Width (between 90% point at leading edge and 10% point at falling edge): 2 — 20 μ sec
Load Impedance: 1 K Ω (min.)

In addition to the crowbar trigger external access, the 104 option also includes access (from a rear terminal strip) to the summing point of the supply to enable the dc output voltage to be remotely programmed to zero (± 15 mVdc max.) with a contact closure.

1-12 ACCESSORIES

1-13 The accessories listed below may be ordered with the power supply or separately from your local Hewlett-Packard field sales office (refer to list at rear of manual for addresses).

| HP Part No. | Description |
|-------------|---|
| 62410A | Rack Mounting Tray for mounting any combination of supplies. 19" wide, 5-1/4" high, and 17" deep. (Refer to Section II for details.) |
| 62411A | Rack Tray Blank Front Panel, 10-1/2" wide, 5-3/16" high, 1/8" thick. |
| 62412A | Rack Tray Blank Rear Panel, mounts on rear of rack mounting tray and allows installation of custom input/output connectors or other hardware. |
| 62415A | Rack Tray AC Distribution Panel mounts on rear of rack mounting tray and includes ac input terminal strip and line card. |
| 62414A | Rack Tray Slides provide easy access to rack mounting tray and its supplies. |
| 62413A | Rack Mounting Tray Cooling Unit provides forced air cooling of rack-mounted supplies. |

1-14 INSTRUMENT/MANUAL IDENTIFICATION

1-15 Hewlett-Packard power supplies are identified by a two-part serial number. The first part is the serial number prefix, a number-letter combination that denotes the date of a significant design change and the country of manufacture. The first two digits indicate the year (10 = 1970, 11 = 1971, etc.), the second two digits indicate the week, and the letter "A" designates the U.S.A. as the country of manufacture. The second part is the power supply serial number; a different sequential number is assigned to each power supply, starting with 00101.

1-16 If the serial number on your instrument does not agree with those on the title page of the manual, Change Sheets supplied with the manual or Manual Backdating Changes define the differences between your instrument and the instrument described by this manual.

1-17 ORDERING ADDITIONAL MANUALS

1-1B One manual is shipped with each power supply. Additional manuals may be purchased from your local Hewlett-Packard field office (see list at rear of this manual for addresses). Specify the model number, serial number prefix, and HP Part number provided on the title page.

SECTION II INSTALLATION

2-1 INITIAL INSPECTION

2-2 Before shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the instrument is unpacked, inspect for any damage that may have occurred in transit. Save all packing materials until the inspection is completed. If damage is found, a claim should be filed with the carrier immediately. Also, a Hewlett-Packard Sales and Service office should be notified.

2-3 Mechanical Check

2-4 This check should confirm that there are no broken connectors and that the panel surfaces are free of dents and scratches.

2-5 Electrical Check

2-6 The instrument should be checked against its electrical specifications. Section V includes an "in-cabinet" performance check to verify proper instrument operation.

2-7. INSTALLATION DATA

2-8 The instrument is shipped ready for bench operation. It is necessary only to connect the instrument to a source of power and it is ready for operation.

2-9 Location

2-10 This instrument is air cooled. Sufficient space should be allotted so that a free flow of cooling air can reach the instrument when it is in operation. At least 1/2-inch clearance at the bottom of the unit is recommended to permit proper air flow. The supply should be used in an area where the ambient temperature does not exceed 50°C. If operated at an ambient greater than 50°C, the supply's output current must be linearly derated down to 50% at 71°C.

NOTE

If the power supply must be operated in a restricted air flow environment, the supply's power consumption (and heat dissipation requirements) can be minimized by operating at low line input voltage. Consult your nearest HP sales engineer for more information on the cooling requirements for your specific operation

2-11 Mounting Orientation

2-12 Figure 2-1 shows outline and dimension information for each modular power supply size. As shown, holes are provided on three surfaces of the supplies any of which can be used to install the supply in the upright position. If the top mounting holes are used; however, be sure that a rigid top support is employed to support the weight of the unit(s). Note that if any other orientation other than upright is required, adequate air flow must be provided; see your nearest HP sales engineer for additional information.

2-13 Rack Mounting

2-14 The modular power supplies can be readily mounted in any combination in a standard 19-inch rack using the Hewlett-Packard Rack Mounting Tray, Model 62410A. The supplies are mounted upright and attached to the tray using the two (A— suffix models) or four (C— and E— suffix models) 10-32 threaded mounting holes located in the bottom of the supply case. The maximum number of supplies that can be mounted in the tray depends on the types of supplies used. For example, if all 1/8-width (A— suffix) supplies are employed, eight modular power supplies can be mounted in the tray. Of course, the tray does not have to be filled to capacity.

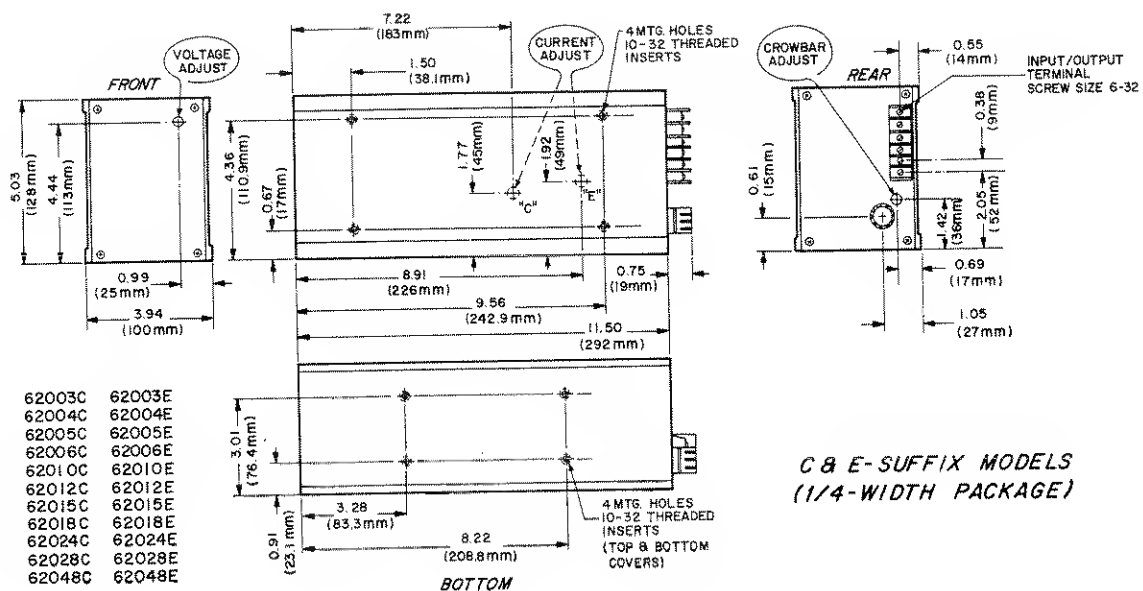
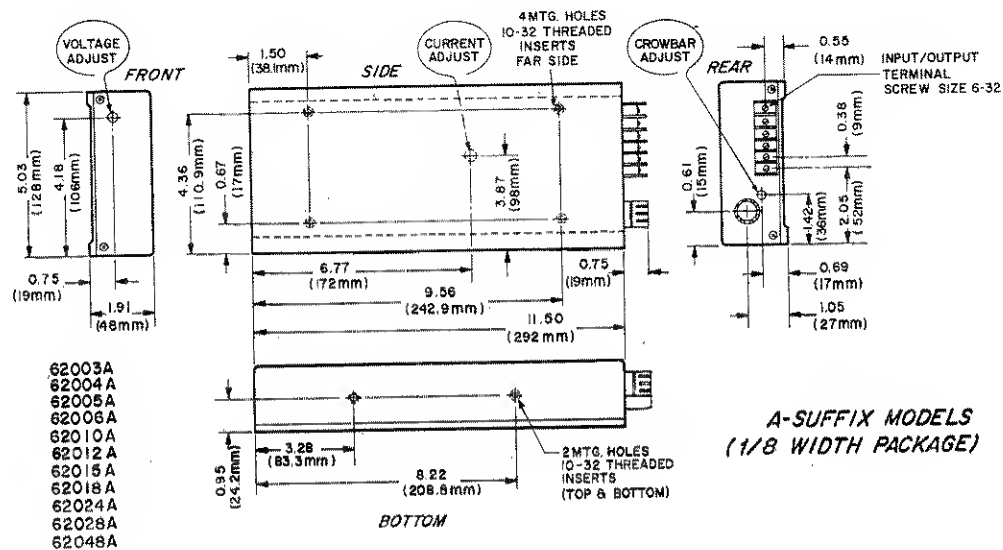


Figure 2-1. Outline Diagrams, Modular Power Supplies

2-15 INPUT POWER REQUIREMENTS

2-16 The modular power supplies may be operated from a nominal 120 Vac, 220 Vac, or 240 Vac, 48-63 Hz, power source. The standard supply (no options) is shipped from the factory wired for 120 Vac (nominal) operation and requires the following maximum input current and power at high line (127 Vac) voltage input:

| MODEL | AC INPUT at 127 Vac | |
|--------|---------------------|--------------|
| | CURRENT (Max.) | POWER (Max.) |
| 62003A | .30A | 31W |
| 62003C | .77A | 74W |
| 62003E | 1.38A | 143W |
| 62004A | .33A | 34W |
| 62004C | .78A | 76W |
| 62004E | 1.42A | 149W |
| 62005A | .37A | 37W |
| 62005C | .80A | 79W |
| 62005E | 1.53A | 160W |
| 62006A | .36A | 37W |
| 62006C | .80A | 79W |
| 62006E | 1.56A | 161W |
| 62010A | .39A | 39W |
| 62010C | .98A | 97W |
| 62010E | 1.87A | 192W |
| 62012A | .47A | 47W |
| 62012C | 1.00A | 100W |
| 62012E | 1.89A | 191W |
| 62015A | .45A | 46W |
| 62015C | .99A | 97W |
| 62015E | 1.82A | 181W |
| 62018A | .42A | 42W |
| 62018C | .97A | 95W |
| 62018E | 1.93A | 196W |
| 62024A | .39A | 39W |
| 62024C | .93A | 88W |
| 62024E | 1.95A | 198W |
| 62028A | .44A | 44W |
| 62028C | .91A | 86W |
| 62028E | 1.87A | 190W |
| 62048A | .47A | 47W |
| 62048C | .97A | 95W |
| 62048E | 2.00A | 193W |

2-17 220/240 VOLT OPERATION

2-18 As applicable, Options 101, 102, and 103 (installed at the factory) permit the supply to be operated from a 120, 220, or 240 Vac (nominal) input line. Option 101 provides for 220 Vac operation while Option 102 allows 240 Vac operation. Option 103, however, provides for either 120 Vac or 240 Vac operation at the selection of the user as described below.

2-19 Option 103 Power Transformer Connections, A— suffix Models. For the A— suffix models, the primary connections of the supply are changed at the in-board side of the rear power input terminals. For 120 Vac operation (as shipped), two leads are soldered from each of the ac input terminals as shown in Figure 2-2B. To connect the supply for 240 Vac operation, unsolder the wht/blk/yel and wht/blk/grn leads and twist them together with a wire terminal as shown in Figure 2-2A.

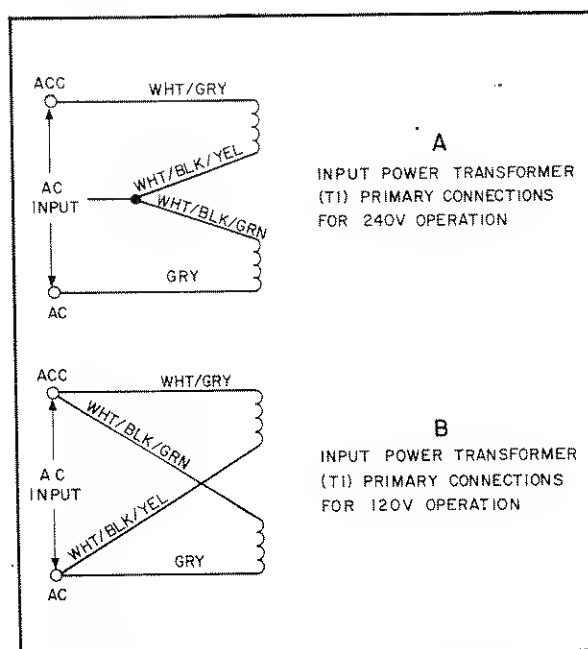
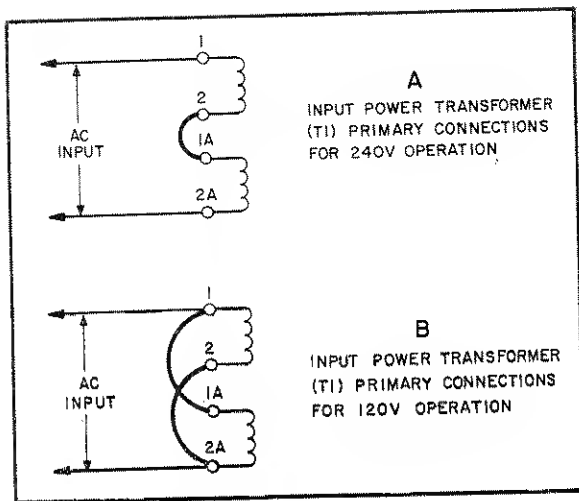


Figure 2-2. Primary Connections For 120/240 Vac Operation (Option 103) – A Suffix Models Only

2-20 Option 103 Power Transformer Connections, —C and E— Suffix Models. For the C— and E— suffix models, the appropriate power transformer 120/240 V terminals must be connected as shown in Figure 2-3. Notice that the transformer connections are changed at the transformer terminals shown in the illustration.



**Figure 2-3. Primary Connections For
120/240 Vac Operation (option 103)
-C and -E Suffix Models Only**

2-21 REPACKAGING FOR SHIPMENT

2-22 To insure safe shipment of the instrument, it is recommended that the package designed for the instrument be used. The original packaging material is reusable. If it is not available, contact your local Hewlett-Packard field office to obtain the materials. This office will also furnish the address of the nearest service office to which the instrument can be shipped. Be sure to attach a tag to the instrument which specifies the owner, model number, full serial number, and service required, or a brief description of the trouble.

SECTION III OPERATING INSTRUCTIONS

3-1 TURN-ON CHECKOUT PROCEDURE

3-2 The following checkout procedure describes the use of the voltage control and ensures that the supply is operational.

a. Before connecting input power to unit, connect external voltmeter across +S and -S terminals at rear terminal board.

b. Connect unit to input power source using AC, ACC, and ground terminals at rear. (Use proper wire size in accordance with the input AC current rating.)

c. Observe output voltage of supply on external meter. Output is factory set to nominal voltage. If desired, VOLTAGE ADJUST (screwdriver control, accessible through cutout on front panel) potentiometer can be used to set output to any voltage within adjustment span (± 0.5 V or $\pm 5\%$ as applicable).

NOTE

The current limit may require readjustment if the output voltage is set away from nominal. Refer to Paragraph 3-8.

d. To verify operation of current limit circuit, remove voltmeter and disconnect input power. Connect short across output terminals of supply and reconnect input power. Using clip-on milliammeter (HP Model 428B, or equivalent) observe that short circuit output current is approximately 3% to 15% of rated output current.

e. Remove short and milliammeter. *Before connecting actual load to supply, read the following paragraphs.*

3-3 OPERATION

3-4 The supply can be operated in one of two operating modes; normal or remote sensing. Auto-Series, Auto-Parallel, Auto-Tracking and remote programming operation are not feasible with this supply. The follow-

ing paragraphs describe both of those modes plus supplementary operating information. More theoretical descriptions regarding the operational features of power supplies in general are given in application note 90A, DC Power Supply Handbook (available at no charge from your local HP sales office).

3-5 Normal Operating Mode

3-6 The power supply is shipped with the rear terminal straps connected for Constant Voltage/Current Limiting, local sensing, operation. This strapping pattern is illustrated in Figure 3-1. Before connecting a load to the supply, check the rear terminals to ensure that the connections are correct and that the connecting straps are tightened securely.

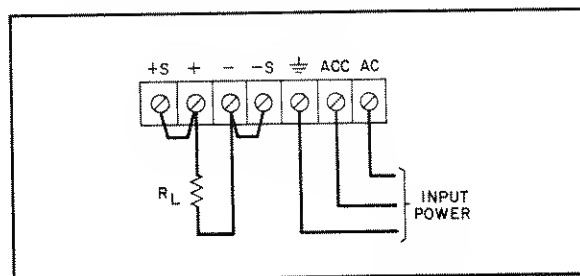


Figure 3-1. Normal Strapping

3-7 Current Limit

3-8 Figure 3-2 shows typical current limiting characteristics for all HP modular supplies. As indicated on the drawing, the current limit point varies in accordance with the output voltage. As received from the factory, the initial current limit point is set to $104 \pm 1\%$ of the current rating with the output voltage at its nominal value. This same current limit setting is recommended for all output voltages within the adjustment span because: (1) the current limit crossover point must be at least 3% higher than the maximum expected operating current to prevent performance degradation; and (2) a current limit setting of higher than 105% of rating creates the possibility of excessive internal heating as specified in the caution note of Figure 3-2. Hence, the current limit potentiometer (accessible through a

cutout in the side panel) may have to be readjusted to satisfy the above two requirements if the user intends to operate at an output voltage which is above or below nominal. For example, if the user has a supply of 10 Volts or above and requires an output voltage of +5% above nominal, the initial current limit point would be factory set to approximately 109% of rating. This violates the 105% current limit constraint mentioned previously and, thus, the current limit potentiometer would have to be adjusted (described in Section V) so that the current limit point is moved to $104 \pm 1\%$ at the upper voltage limit rather than at nominal voltage.

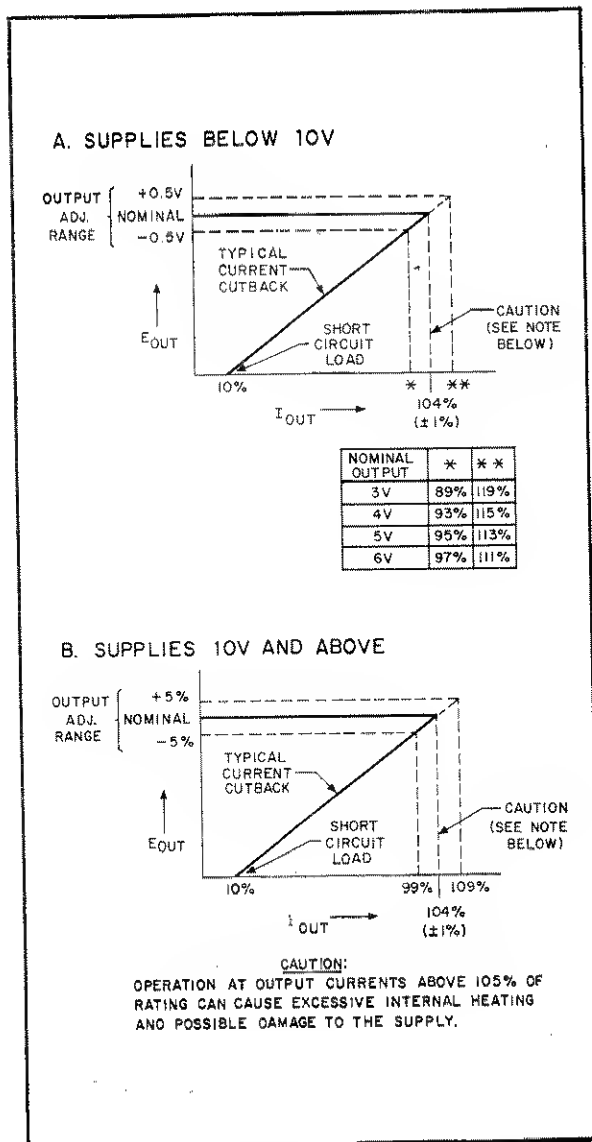


Figure 3-2. Typical Current Limiting Characteristics

3-9 Connecting Load

3-10 Each load should be connected to the proper supply output terminals using separate pairs of connecting wires. This will minimize mutual coupling effects between loads and will retain full advantage of the low output impedance of the power supply. Each pair of connecting wires should be as short as possible and twisted or shielded to reduce noise pickup. (If a shield is used, connect one end to power supply ground terminal and leave the other end unconnected.)

3-11 If load considerations require that the output power distribution terminals be remotely located from the power supply, then the power supply output terminals should be connected to the remote distribution terminals via a pair of twisted or shielded wires and each load separately connected to the remote distribution terminals. For this case, remote sensing should be used (Paragraph 3-13).

3-12 Positive or negative voltages can be obtained from this supply by grounding either one of the output terminals or one end of the load.

3-13 Remote Sensing (See Figure 3-3)

3-14 Remote sensing is used to maintain good regulation at the load by reducing the degradation in regulation that would occur due to the voltage drop in the leads between the power supply and the load. Remote sensing is accomplished by utilizing the strapping pattern shown in Figure 3-3. The power supply should be turned off before changing strapping patterns. The leads from the sensing terminals to the load will carry much less current than the load leads and it is not required that these leads be as heavy as the load leads. However, they must be twisted or shielded to minimize noise pick-up.

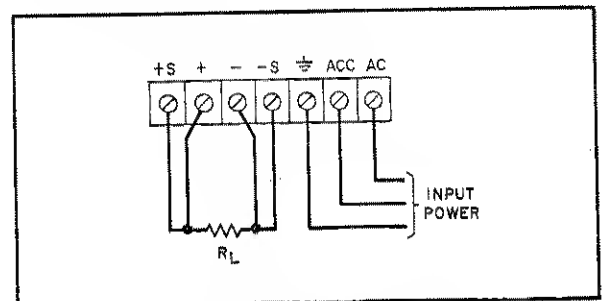


Figure 3-3. Remote Sensing

3-15 For reasonable load lead lengths, remote sensing greatly improves the performance of the supply. However, if the load is located a considerable distance from the supply, added precautions must be observed to obtain satisfactory operation. Notice that the voltage drop in the load leads subtracts directly from the available output voltage and also reduces the amplitude of the feedback error signals that are developed within the unit. Because of these factors it is recommended that the total drop in both load leads not exceed 0.5 V. If a larger drop must be tolerated, please consult your local HP sales engineer.

NOTE

Due to the voltage drop in the load leads, it may be necessary to readjust the current limit. Refer to Paragraph 3-8.

3-16. It should be noted that a problem can occur in obtaining maximum rated output voltage (nominal +0.5 V) from a lower voltage supply (below 10 V) even if the total voltage drop in both load leads is maintained at 0.5 Volt. This problem is most likely to occur when the input ac is at low line. To counteract this effect, the user can maintain the ac input at a higher line voltage or reduce the voltage drop in the load leads by using larger diameter wires.

3-17 SPECIAL OPERATING PRECAUTIONS

3-18 Temperature

3-19 The normal operating temperature for this supply is from 0 to 50°C, ambient. Beyond 50°C, the output current is linearly derated to 50% at 71°C. Additional information on temperature is given in Section II.

NOTE

During normal operation of the supply, the case of the unit may become hot to the touch. This is a normal occurrence and no cause for alarm.

3-20 Mounting Orientation

3-21 The supply should be mounted and operated in the upright position as instructed in Section II. If the supply must be operated in an orientation other than upright, an adequate flow of cooling air must be maintained. Contact your nearest HP sales engineer for details.

SECTION IV PRINCIPLES OF OPERATION

4-1 OVERALL DESCRIPTION

4-2 Figure 4-1 is a simplified schematic of the power supply indicating all of its major circuits. Except for minor variations (discussed later in Section IV) the Hewlett-Packard modular supplies covered by this manual are as shown in Figure 4-1. Notice that each stage of the supply has been designated according to function. These functional designations also appear on the applicable schematic at the rear of the manual so that both diagrams can be correlated.

4-3 The ac input voltage is reduced to the proper level by the power transformer and fed to the rectifier-filter where it is converted to raw (unregulated) dc. The raw dc voltage is adjusted by the series regulator so that a regulated, constant voltage is available across the output terminals of the supply.

4-4 The series regulator, part of a feedback loop, alters its conduction in accordance with the feedback control signals obtained from the driver. The driver, in turn, is controlled by feedback signals originated in

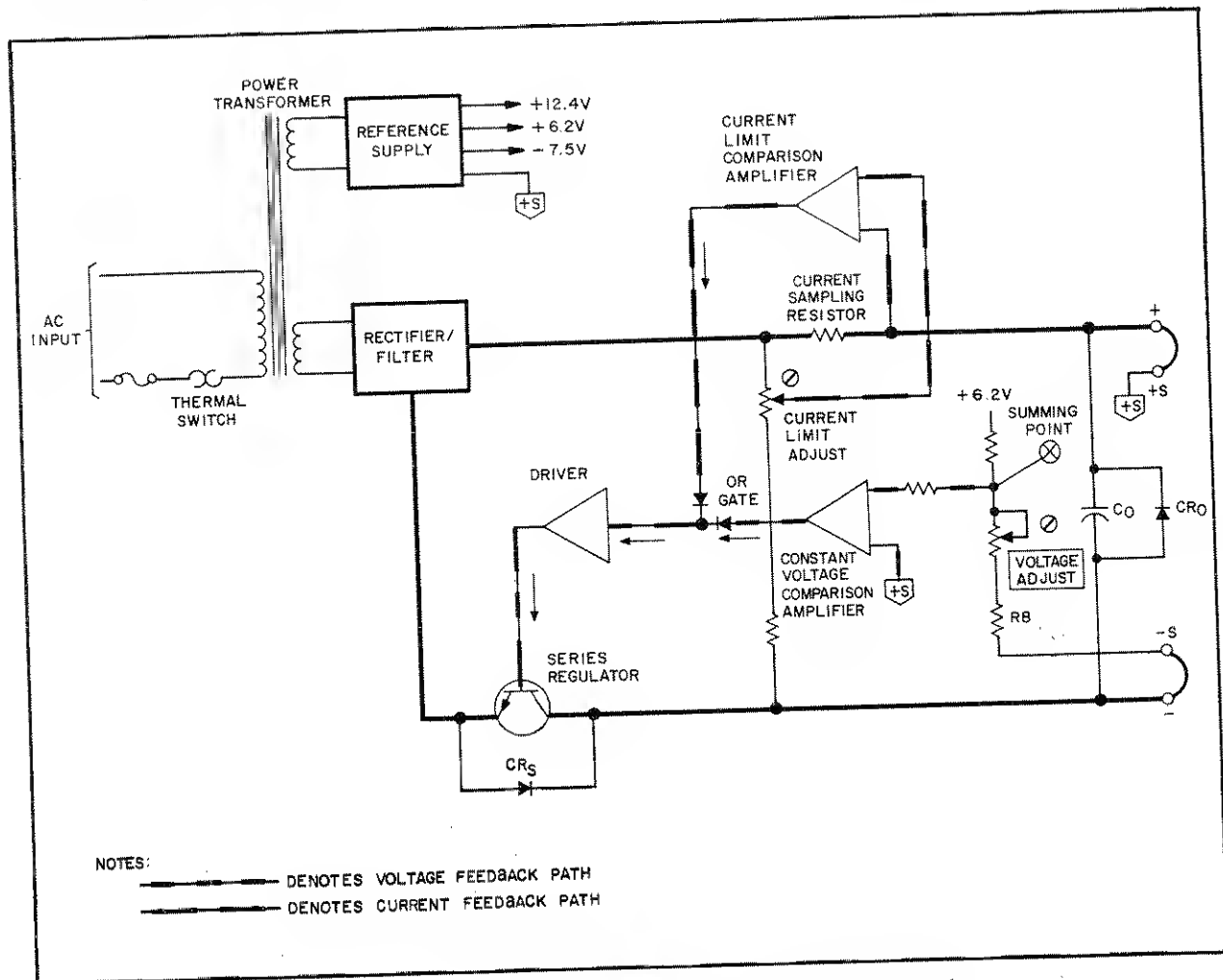


Figure 4-1. Typical Modular Power Supply, Simplified Schematic

the voltage comparison amplifier, during constant voltage operation, or the current limiting amplifier during current limit operation.

4-5 The reference supply provides regulated bias voltages which are used by the internal circuitry throughout the main power supply.

4-6 DETAILED DESCRIPTION

4-7 The following paragraphs describe in detailed terms, the operation of each of the supply's major circuits. Throughout this discussion, refer to both the simplified schematic of Figure 4-1 and the appropriate schematic diagram at the rear of the manual.

4-8 Feedback Loop

4-9 The voltage comparison amplifier, together with the driver and series regulator, comprises the constant voltage feedback loop. This feedback loop maintains a constant output voltage during normal (constant voltage) operation. To accomplish this, the voltage comparison amplifier continuously monitors the output voltage of the supply. It detects instantaneous changes in the output and applies an amplified error signal to the series regulator (via the driver) which is of the correct phase and amplitude to counteract the change.

4-10 The feedback loop also prevents the output current from exceeding a preset current limit value. Current limiting operation is initiated by the current limit comparison amplifier which conducts if the output current that flows through the current sampling resistance exceeds a value established by the current limit-adjust potentiometer. When conducting, this amplifier sends a turn-down signal to the series regulator, via the driver.

4-11 An output capacitor, C_O , connected across the output of the supply, helps to stabilize the feedback loop regardless of the type of load that is imposed.

4-12 Constant Voltage Comparison Amplifier

4-13 This circuit consists of the VOLTAGE ADJUST potentiometer R7 and a differential amplifier stage (U2 and associated components). An integrated circuit is used for the differential amplifier for increased reliability and to minimize differential voltages due to mis-matched transistors and thermal differentials.

4-14 The voltage comparison amplifier continuously compares the output voltage of the supply with the voltage drop between the $-S$ terminal and the circuit's summing point (junction at voltage divider R5, R7, and R8). If these two voltages are momentarily unequal, an error voltage is generated whose amplitude is proportional to the difference. The error signal ultimately alters the conduction of the series regulator which, in turn, alters the output current so that the output voltage becomes equal to the voltage at the summing point. Hence, through feedback action, the difference between the two inputs to U2 is held at nearly zero volts.

4-15 The inverting input of the comparison amplifier (pin 2 of U2) is connected, through jumper W1 to the constant voltage summing point. (As indicated on NOTE 7 of each schematic, W1 is connected either to the junction of R5, R7 for supplies below 10 V or to the junction of R7, R8 for supplies 10 V and above.) The non-inverting input to the comparison amplifier (pin 3 of U2) is connected directly to the output voltage sensing terminal (+S) of the supply. Instantaneous changes in the output voltage, or changes at the summing point due to rotation of the voltage pot, produce a difference voltage between the two inputs of the comparison amplifier. This difference voltage is amplified and appears at the output of the amplifier, at pin 6.

4-16 Capacitor C12 and resistor R10 couple rapid output voltage variations to the input of U2 while slower (dc) changes are coupled to U2 via resistor R8. Diodes CR11 and CR12 prevent excessive voltage excursions from over-driving the comparison amplifier; RC network R12, C13 provide degenerative feedback to help stabilize the feedback loop.

4-17 Driver

4-18 The driver amplifies the error signal from the constant voltage or current limit comparison amplifiers to a level sufficient to drive the series regulating transistor(s). Inverting stage Q2 receives its input signal from the OR-gate diode (CR13 or CR14) that is conducting at the time. During normal (constant voltage) operation, CR13 is forward biased and CR14 is reverse biased. The reverse is true during current limiting operation.

4-19 Stage Q2 provides mainly voltage amplification of the feedback signal while emitter follower Q3 provides most of the current gain. Some models; e.g. 62048A, contain only one driver stage (Q2) instead of two.

4-20 Feedback capacitor C18 provides degenerative feedback to Q3 to prevent oscillation and C19 helps shape the high frequency rolloff of the feedback loop response curve. R28 provides a leakage current path for transistor Q3.

4-21 Series Regulator

4-22 The series regulator, or series control element, acts as a variable resistance connected in series with the load. Its conduction is controlled by the feedback signals from the driver so that the output voltage is maintained constant or the current limit is not exceeded. A diode (CR₅ on Figure 4-1) connected across the regulator, protects the series element(s) from possible damage by a reverse current flow.

4-23 Many modular power supplies employ one series transistor as indicated on Figure 4-1. However, higher power units (such as Models 62003E thru 62048E) use two regulating transistors, connected in parallel to minimize power dissipation. Approximately half of the output current flows through each transistor.

4-24 Current Limit Comparison Amplifier

4-25 This circuit consists of current limit adjust potentiometer R18 and a differential amplifier stage (U3 and associated components). Stage U3 is similar in appearance and operation to the constant voltage comparison amplifier, U2.

4-26 The current limit comparison amplifier effectively monitors the output current of the supply by monitoring the IR drop across current sampling resistor R15. The voltage drop across R15 is compared with a reference voltage established by the setting of current limit potentiometer R18. During constant voltage operation, the output of U3 is not positive enough to forward bias OR gate diode CR14. However, if the output current increases to approximately 104% of the rated value, the input to pin 2 of U3 is driven momentarily less positive. If this occurs, a positive going output signal from U3 forward biases CR14 and reverse biases CR13. This feedback signal then decreases the conduction of the series regulator.

4-27 The current limiting circuit contains a current "cutback" feature which protects the series regulating transistor(s) against excessive overloads. As the load resistance decreases, the output current is cut back linearly, from the initial current limit point, to approximately 10% of the rated current under short circuit conditions (see Figure 4-2). Cutback action is made possible by R18 and R19, which are connected across the output of the supply. If the load resistance decreases after the initial current limiting point, the resultant drop in output voltage causes a decrease in the current flowing through R18 and R19. This, in turn, causes U3 to conduct even harder further reducing the conduction of the series regulator.

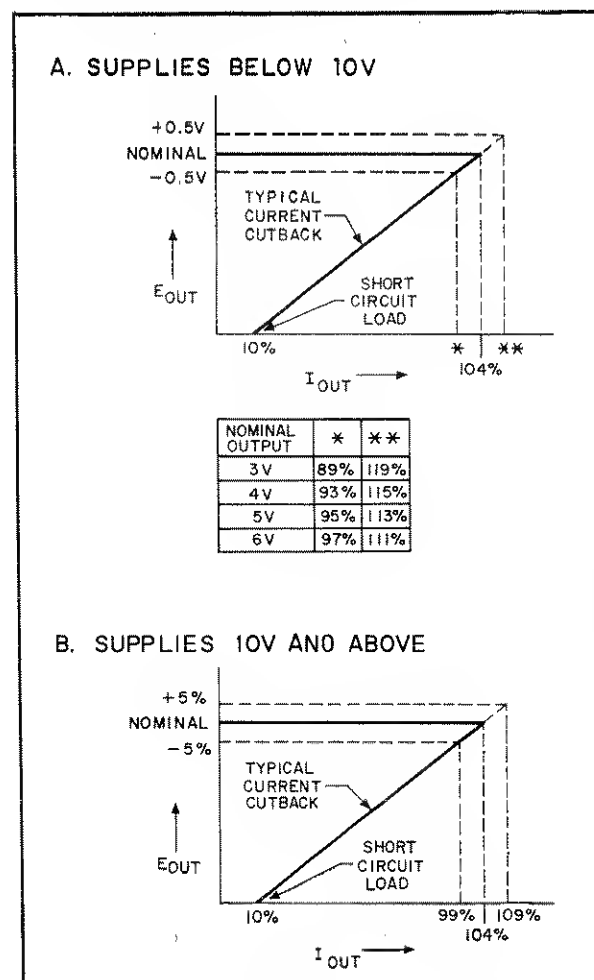


Figure 4-2. Typical Current Limiting Characteristics

4-28 As described in Section III, the cutback point for the supply can vary from approximately 3% to 15% of the rated output current. Resistors R20 and R21 determine the actual cutback point.

4-29 Reference Supply

4-30 The reference supply is a small regulated bias source which is similar to the main power supply. It contains a series regulator (Q1) and a comparison amplifier (U1). The three reference voltages are all derived from raw dc obtained from a full-wave rectifier (CR1 and CR2) and filter capacitor C1. The +6.2V and -7.5V outputs are developed across Zener diodes VR1 and VR2. The reference Zener diode (VR2) is temperature compensated. Resistor R4 limits the current through VR2 to establish an optimum bias level.

4-31. The regulating circuit consists of U1, Q1, and associated components. The voltage across the reference zener (+6.2 V with respect to +S) and the voltage at the junction of divider R2 and R3 are compared and any differences are detected by U1. The error voltage is then amplified and applied to series regulator Q1 to counteract the difference and maintain the +12.4 V output constant. Output capacitor C3 stabilizes the reference regulator feedback loop to prevent oscillation.

4-32 Zener diode VR1 provides an additional reference voltage of -7.5 V. This voltage is not as tightly regulated as the other two reference voltages since it is not controlled by the regulator circuit. The unregulated +23 V, taken directly from the rectifier, is used only by Option 011 or 104 crowbar circuits.

4-33 Additional Protection Features

4-34 The supply contains several "special purpose" components which protect the supply in the event of unusual circumstances. One of these is the output diode (CR9 or U5; refer to applicable schematic). Connected across the output terminals, this diode prevents internal damage from reverse voltages that might be applied during system operation when one power supply is turned on before another. The output diode can withstand currents equal to the maximum current rating of the supply for time periods of short duration (approximately 3 minutes); or up to half the current rating of the supply for longer time periods.

4-35 The series regulator diode (CR8 or U5) protects the regulating transistor(s) from the effects of a reverse current which would occur if an external voltage were applied across an unenergized supply.

4-36 Sensing protection resistors R32 and R33 prevent the load from receiving full rectifier voltage if the connections between the output terminals and the sensing terminals (+S and -S) are removed inadvertently.

4-37 Thermal switch TC1 opens if the heat sink temperature exceeds a safe value. With TC1 open, the ac input path to the supply is broken, shutting down the supply. The switch automatically resets after the supply has cooled to a temperature below that at which it originally opened. The opening and closing temperatures for the switch are given in the individual parts list for each supply.

SECTION V MAINTENANCE

5-1 INTRODUCTION

5-2 Upon receipt of the power supply, the performance check of Paragraph 5-6 can be made. This check is suitable for incoming inspection. Section III contains a quick but less comprehensive checkout procedure which can be used in lieu of the performance check, if desired.

5-3 If a fault is detected in the power supply while making the performance check or during normal operation, proceed to the troubleshooting procedures

(Paragraph 5-37). After troubleshooting and repair (Paragraph 5-54) repeat the performance check to ensure that the fault has been properly corrected and that no other faults exist. Before performing any maintenance checks, turn on the power supply and allow a half-hour warm-up.

5-4 TEST EQUIPMENT REQUIRED

5-5 Table 5-1 lists the test equipment required to perform the various procedures described in this section.

Table 5-1. Test Equipment Required

| TYPE | REQUIRED CHARACTERISTICS | USE | RECOMMENDED MODEL |
|-----------------------------------|---|--|--|
| Digital Voltmeter | Sensitivity: 100 μ V full scale (min.). Input impedance: 10 megohms (min.). | Measure DC voltages: calibration procedures | HP 3450A |
| Variable Voltage Transformer | Range: 90–130Vac. Equipped with voltmeter accurate within 1 Volt | Vary AC input | --- |
| Oscilloscope | Sensitivity: 100 μ V/cm. Differential input. | Display transient response and ripple/noise waveforms; current limit adjustment. | HP140B plus 1400B plug-in. 1402A plug-in for noise measurements. |
| Repetitive Load Sw. | Rate: 60Hz, 2 μ sec. rise and fall time. | Measure transient response. | See Figure 5-4. |
| Resistive Load | Value: See Paragraph 5-11. Tolerance: \pm 5% | Power supply load resistor. (Fixed resistor or Rheostat). | James G. Biddle "Lubri-Tact" Rheostat 411G23CS or 411G85CS. |
| Current Sampling Resistor (Shunt) | Value: See Paragraph 5-13. Accuracy: 1% (minimum) | Measure output current | Simpson Portable Shunt, 06704. |

5-6 PERFORMANCE TEST

5-7 The following test can be used as an incoming inspection check and appropriate portions of the test can be repeated to check the operation of the instrument after repairs. The tests are performed using the nominal 120VAC, 60Hz, input power for the unit. If the correct result is not obtained for a particular check, proceed to troubleshooting (Paragraph 5-37).

5-8 Measurement Techniques

5-9 **Connecting Monitoring Device.** For the following Constant Voltage measurements, the measuring device must be connected across the rear sensing terminals of the supply in order to achieve valid indications. A measurement made across the load includes the impedance of the leads to the load and such lead lengths can easily have an impedance that is greater than the supply impedance, thus invalidating the measurement. To avoid mutual coupling effects, each monitoring device must be connected directly to the sensing terminals by separate pairs of leads.

5-10 **Avoid Current Limiting.** When measuring the constant voltage performance specifications, the current limit point should be set at least 3% above the maximum output current which the supply will draw, since the onset of current limiting action will cause a drop in output voltage, increased ripple, and other changes not properly ascribed to the constant voltage operation of the supply. The current limit potentiometer is factory set to its proper value when the supply is providing nominal output voltage. If an output voltage other than nominal is selected, read Paragraph 3-8 and then proceed to the current limit adjustment procedure, Paragraph 5-72.

5-11 **Selecting A Load Resistor.** Constant voltage specifications are checked with a "full" load resistance connected across the supply. The resistance and wattage of the load resistor, therefore, must permit operation of the supply at its rated output voltage and current. For example, a supply that is rated at 4 ± 0.5 volts and 4 amperes would require a load resistance of 1 ohm at the nominal output voltage (4V). If the output voltage were set to one of the adjustment limits (4.5V or 3.5V), the load resistance would have to increase or decrease accordingly, to allow the unit to provide its rated current of 4 amperes. The wattage rating of the 1 ohm resistor would be 4 watts, minimum.

5-12 Either a fixed or variable resistor (rheostat) can be used as the load resistance. A rheostat is very useful when measuring the output current of the supply and also is a convenience if the user is testing a number of modular power supplies of different ratings. A rheostat of the type recommended in Figure 5-1 is adequate for any supply covered by this manual. If a fixed resistor is used for output current measurements, its tolerance must be accounted for in evaluating the test results.

5-13 **Output Current Measurements.** For accurate output current measurements a current sampling resistor should be inserted between the load resistor and the output of the supply. An accurate voltmeter is then placed across the sampling resistance and the output current at any time can be calculated by dividing the voltage across the sampling resistor by its ohmic value. The total resistance of the series combination (sampling resistor and load resistor) should be equal to the full load resistance as determined in the preceding paragraphs. Of course, if the value of the sampling resistance is very low when compared to the full load resistance, the value of the sampling resistance may be ignored. The meter shunt recommended in Table 1-1, for example, has a resistance of only 5 milliohms and can be neglected when calculating the load resistance of the supply.

5-14 Figure 5-1 shows a four terminal meter shunt. The load current is fed to the extremes of the wire leading to the resistor while the sampling terminals are located as close as possible to the resistance portion itself.

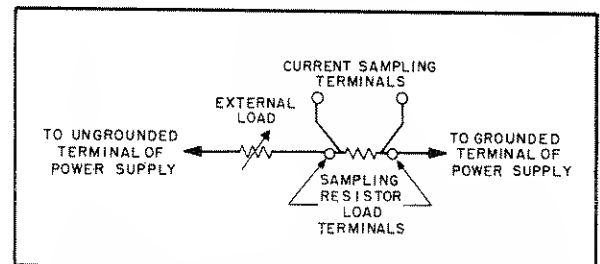


Figure 5-1. Current Sampling Resistor Connections

5-15 Rated Output

5-16 **Voltage.** To ensure that the supply will furnish the maximum rated output voltage, proceed as follows:

- a. Connect digital voltmeter across +S and -S terminals of supply observing correct polarity.

- b. Apply input power to supply.
- c. With no load connected, set output voltage of supply to any value desired within adjustment span. This output voltage can be used for all remaining constant voltage tests.

d. With supply off, connect full load resistance across + and - output terminals of supply (see Paragraph 5-11).

e. Reconnect input power to supply. Voltmeter should read output voltage set in Step c (within tolerances of load resistor and meter).

5-17 Current. To ensure that the supply will furnish the maximum rated output current, proceed as follows:

a. Connect test setup shown in Figure 5-2. Select load and current sampling resistor values according to Paragraphs 5-11 and 5-13.

b. Apply input power to supply and adjust R_L until digital voltmeter indicates a voltage drop which is proportional to the maximum rated output current.

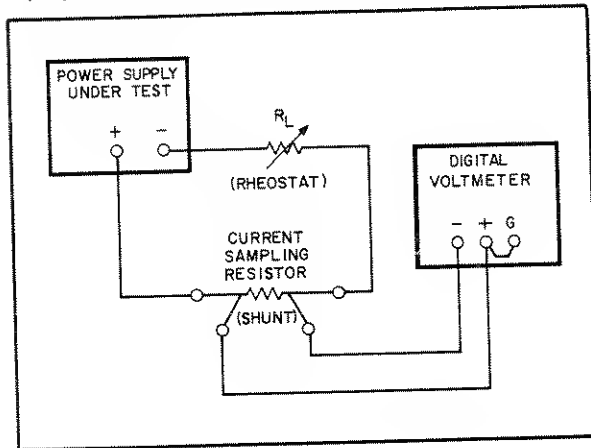


Figure 5-2. Output Current, Test Setup

5-18 Load Regulation

Definition: The change ΔE_{OUT} in the static value of DC output voltage resulting from a change in load resistance from open circuit to a value which yields maximum rated output current (or vice versa).

5-19 To check the constant voltage load regulation, proceed as follows:

a. Connect full load resistance across rear output terminals (Paragraph 5-11).

- b. Connect digital voltmeter across $\pm S$ terminals.
- c. Turn on supply and obtain desired output voltage. Record voltage read on voltmeter.
- d. Disconnect load resistance.
- e. Reading on digital voltmeter should not vary from reading recorded in step c by more than 0.01% or 1mV, whichever is greater.

5-20 Line Regulation

Definition: The change, ΔE_{OUT} , in the static value of DC output voltage resulting from a change in AC input voltage over the specified range from low line (usually 104 Volts) to high line (usually 127 Volts), or from high line to low line.

5-21 To test the line regulation, proceed as follows:

- a. Connect variable auto transformer between input power source and power supply power input terminals.
- b. Connect load resistance and digital voltmeter across output of supply.
- c. Adjust variable auto transformer for low line input.
- d. Turn on setup. Read and record output voltage on digital voltmeter.
- e. Adjust variable auto transformer for high line input.
- f. Reading on digital voltmeter should not vary from reading recorded in step d by more than 0.01% or 1mV, whichever is greater.

5-22 Ripple and Noise

Definition: The residual AC voltage which is superimposed on the DC output of a regulated power supply. Ripple and noise may be specified and measured in terms of its RMS peak-to-peak value.

5-23 Ripple and noise measurement can be made at any input AC line voltage combined with any DC output voltage and load current within rating.

5-24 Figure 5-3A shows an incorrect method of measuring p-p ripple. Note that a continuous ground loop exists from the third wire of the input power cord of

the supply to the third wire of the input power cord of the oscilloscope via the grounded power supply case, the wire between the negative output terminal of the power supply and the vertical input of the scope, and the grounded scope case. Any ground current circulating in this loop as a result of the difference in potential E_G between the two ground points causes an IR drop which is in series with the scope input. This IR drop, normally having a 60Hz line frequency fundamental, plus any pickup on the unshielded leads interconnecting the power supply and scope, appears on the face of the CRT. The magnitude of this resulting signal can easily be much greater than the true ripple developed between the plus and minus output terminals of the power supply, and can completely invalidate the measurement.

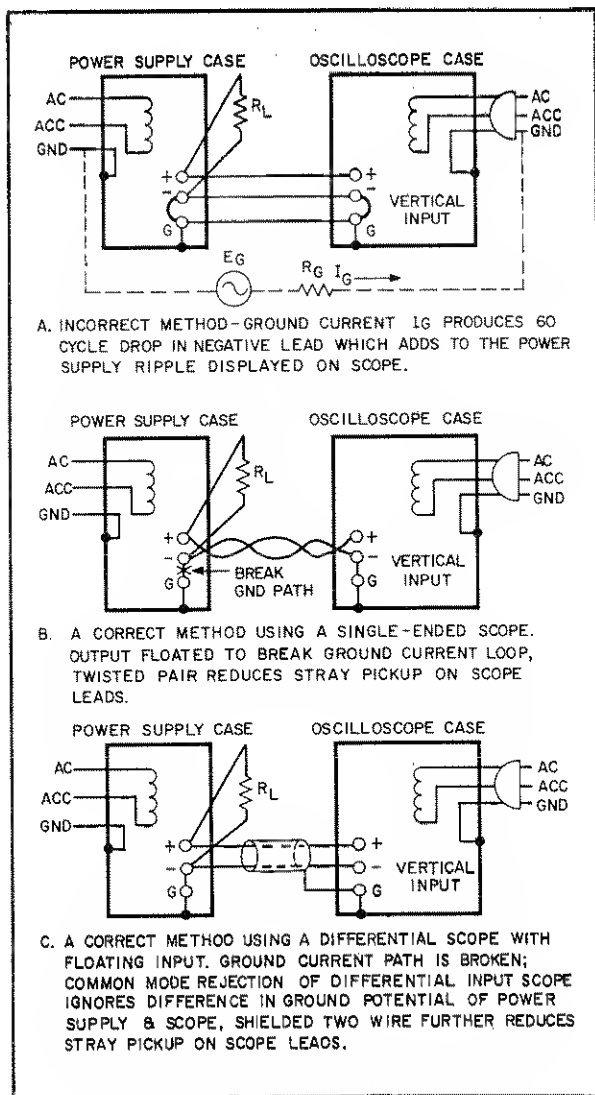


Figure 5-3. Ripple and Noise, Test Setup

5-25 The same ground current and pickup problems can exist if an RMS voltmeter is substituted in place of the oscilloscope in Figure 5-3. However, the oscilloscope display, unlike the true RMS meter reading, tells the observer immediately whether the fundamental period of the signal displayed is 8.3 milliseconds (1/120Hz) or 16.7 milliseconds (1/60Hz). Since the fundamental ripple frequency present on the output of an HP supply is 120Hz (due to full-wave rectification), an oscilloscope display showing a 120Hz fundamental component is indicative of a "clean" measurement setup, while the presence of a 60Hz fundamental usually means that an improved setup will result in a more accurate (and lower) value of measured ripple.

5-26 Figure 5-3B shows a correct method of measuring the output ripple of a constant voltage power supply using a single-ended scope. The ground loop path is broken by floating the power supply output. Note that to ensure that no potential difference exists between the supply and the oscilloscope, it is recommended that whenever possible they both be plugged into the same ac power buss. If the same buss cannot be used, both ac grounds must be at earth ground potential.

5-27 Either a twisted pair or (preferably) a shielded two-wire cable should be used to connect the output terminals of the power supply to the vertical input terminals of the scope. When using a twisted pair, care must be taken that one of the two wires is connected to the grounded input terminal of the oscilloscope. When using shielded two-wire, it is essential for the shield to be connected to ground at one end only to prevent ground current flowing through this shield from inducing a signal in the shielded leads.

5-28 To verify that the oscilloscope is not displaying ripple that is induced in the leads or picked up from the grounds, the (+) scope lead should be shorted to the (—) scope lead at the power supply terminals. The ripple value obtained when the leads are shorted should be subtracted from the actual ripple measurement.

5-29 In most cases, the single-ended scope method of Figure 5-3B will be adequate to eliminate non-real components of ripple so that a satisfactory measurement may be obtained. However, in more stubborn cases, (or if high frequency noise up to 20MHz must be measured), it may be necessary to use a differential scope with floating input as shown in Figure 5-3C. If desired, two single-conductor shielded cables may be substituted in

place of the shielded two-wire cable with equal success. Because of its common mode rejection, a differential oscilloscope displays only the difference in signal between its two vertical input terminals, thus ignoring the effects of any common mode signal produced by the difference in the ac potential between the power supply case and scope case. Before using a differential input scope in this manner, however, it is imperative that the common mode rejection capability of the scope be verified by shorting together its two input leads at the power supply and observing the trace on the CRT. If this trace is a straight line, then the scope is properly ignoring any common mode signal present. If this trace is not a straight line, then the scope is not rejecting the ground signal and must be realigned in accordance with the manufacturer's instructions until proper common mode rejection is attained.

5-30 Ripple and/or noise output measurement procedures are given in the following steps. If a high frequency noise measurement is desired, an oscilloscope with sufficient bandwidth (20MHz) must be used. To measure the ripple/noise output, proceed as follows:

- Connect oscilloscope or RMS voltmeter as shown in Figures 5-3B or 5-3C.
- Connect input power and observe oscilloscope.
- The observed ripple should be less than 1mVrms and 2mV p-p.

5-31 Load Transient Recovery

Definition: The time "X" for output voltage recovery to within "Y" millivolts of the nominal output voltage following a "Z" amp step change in load current — where:

"X" = 50 μ sec, "Y" = 15mV, and "Z" is the specified load current change, equal to half of the current rating of the supply. The nominal output voltage is defined as the DC level half way between the static output voltage before and after the imposed load change.

5-32 Transient recovery time may be measured at any input line voltage combined with any output voltage and load current within rating.

5-33 Reasonable care must be taken in switching the load resistance on and off. A hand-operated switch in series with the load is not adequate, since the resulting one-shot displays are difficult to observe on most oscilloscopes, and the arc energy occurring during switching

action completely masks the display with a noise burst. Transistor load switching devices are expensive if reasonably rapid load current changes are to be achieved.

5-34 A mercury-wetted relay, as connected in the load switching circuit of Figure 5-4 should be used for loading and unloading the supply. When this load switch is connected to a 60Hz AC input, the mercury-wetted relay will open and close 60 times per second. Adjustment of the 25K control permits adjustment of the duty cycle of the load current switching and reduction in jitter of the oscilloscope display. This relay may also be used with a 50Hz ac input.

5-35 The maximum load ratings listed in Figure 5-4 must be observed in order to preserve the mercury-wetted relay contacts. Switching of larger load currents can be accomplished with mercury pool relays; with this technique fast rise times can still be obtained, but the large inertia of mercury pool relays limits the maximum repetition rate of load switching and makes the clear display of the transient recovery characteristic on an oscilloscope more difficult.

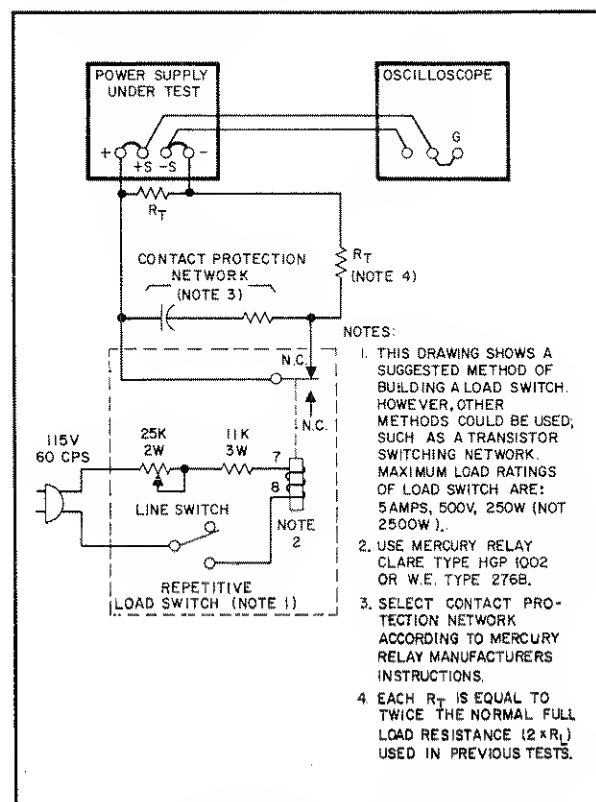


Figure 5-4. Transient Recovery Time, Test Setup

5-36 To check the transient recovery time, proceed as follows:

- a. Connect test setup shown in Figure 5-4. 80h load resistors (R_T) are twice normal value of full load resistance.
- b. Turn on supply and close the line switch on the repetitive load switch setup.
- c. Set the oscilloscope for internal sync and lock on either the positive or negative load transient spike.
- d. Set the vertical input of the oscilloscope for ac coupling so that small dc level changes in the output voltage of the power supply will not cause the display to shift.
- e. Adjust the horizontal positioning control so that the trace starts at a point coincident with a major graticule division. This point is then representative of time zero.
- f. Adjust the vertical centering on the scope so that the tail ends of the no load and full load waveforms are symmetrically displaced about the horizontal center line of the oscilloscope. This center line now represents the nominal output voltage defined in the specification.
- g. Increase the sweep rate so that a single transient spike can be examined in detail.
- h. Adjust the sync controls separately for the positive and negative going transients so that not only the recovery waveshape but also as much as possible of the rise time of the transient is displayed.
- i. Starting from the major graticule division representative of time zero, count to the right $50\mu\text{sec}$ and vertically 15mV . Recovery should be within these tolerances; as illustrated in Figure 5-5.

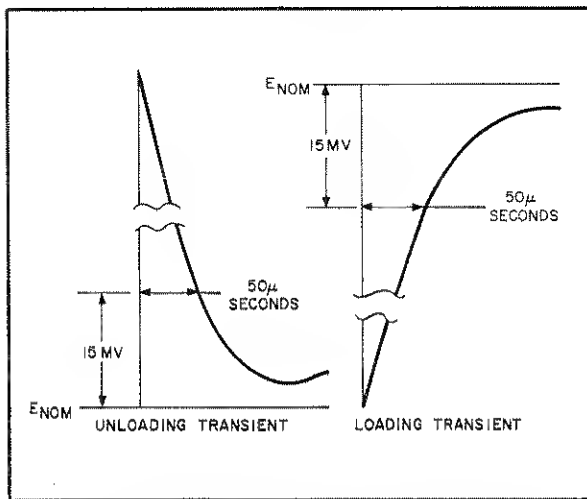


Figure 5-5. Transient Recovery Time Waveforms

5-37 TROUBLESHOOTING

5-38 Before attempting to troubleshoot this instrument, ensure that the fault is with the instrument itself and not with an associated circuit. The performance test enables this to be determined without having to remove the covers from the supply.

5-39 A good understanding of the principles of operation is a helpful aid in troubleshooting, and it is recommended that the reader review Section IV of the manual before attempting to troubleshoot the unit in detail. Once the principles of operation are understood, refer to the initial troubleshooting procedures in Paragraph 5-41 to locate the symptom and probable cause.

5-40 Various lettered test points are located at critical points on the PC board to assist in troubleshooting. These test points are also included on the schematic diagrams at the rear of the manual.

5-41 Initial Troubleshooting Procedures

5-42 If a malfunction occurs, proceed as follows:

- (1) Disconnect input power and remove all loads from unit.
- (2) Ensure that +S and -S terminals are strapped securely to proper output terminals.
- (3) Measure output voltage across sensing terminals and proceed to Table 5-2 to locate your symptom and appropriate isolation procedures.

5-43 Open Fuse Troubleshooting

5-44 Although an open line fuse can be caused by fatigue or line transients, it is recommended that the unit be first checked for internal shorts before replacing the fuse. To accomplish this test, follow the below steps in sequence:

- (1) Visually inspect the unit for charred components, foreign matter, and obvious shorts.
- (2) With power removed, connect an ohmmeter between + output terminal and test point F on the P.C. board. Reading should not be less than the value of R31 (between 200 and 5,600 ohms, depending upon the model number) after filter capacitor C9 becomes charged. If resistance is less than R31, check C9, CR3, 4, 5, 6, (or U4), Q4, (Q5), CR8 (or U5), CR9 (or U5) or C11 for short.
- (3) Connect ohmmeter across reference supply filter capacitor (test points B and N). Reading should

be at least 5,000 ohms. If less, check C1, CR1, or CR2 for short.

(4) Connect ohmmeter across power transformer (ACC terminal and test point F). Reading should be at least 10 Megohms. If it is less, check T1 for shorts or leakage.

(5) If the previous steps prove satisfactory, or if a trouble was found and corrected, replace line fuse and reconnect input power.

5-45 Current Limit Troubleshooting

5-46 Improper activation of the current limit protection circuit can be caused by one of two conditions: (1) a failure within the supply; or (2) activation of the optional crowbar SCR (option 011 or 104). Table 5-5

shows the recommended method of isolating the trouble to either the supply itself or the crowbar. Failures within the main supply are covered in Table 5-5 while crowbar problems are referenced to a separate table.

5-47 Excessive Ripple Troubleshooting

5-48 If excessive ripple or noise is encountered, the frequency of the ripple should be determined as the first step in isolating the trouble. Ripple or spikes occurring at the line or twice the line frequency, are usually caused by problems in the reference supply or the main rectifier area of the supply. Refer to the next paragraph if this problem occurs. Higher frequency noise ("hash") occurring at a fixed frequency are

Table 5-2. Initial Troubleshooting

| SYMPTOM | CHECK | RESPONSE — PROBABLE CAUSE |
|--|--|---|
| Low output voltage (less than 1.5V) | Check fuse F1 | a. Fuse blown, Internal short — proceed to Paragraph 5-43. b. Fuse good. Series regulator loop or reference supply defective — proceed to Table 5-3. |
| High output voltage (above maximum rating) | ---- | a. Series regulator loop defective — proceed to Table 5-4. |
| High ripple | Check operating setup for ground loops | a. Refer to paragraph 5-24 for ground loop information. b. If setup is free of ground loops, reference supply or main rectifier may be defective — proceed to Paragraph 5-47. c. Supply may be operating too close to current limit crossover point — read Paragraph 5-10, then Paragraph 5-45. |
| Will not current limit | ---- | a. OR-gate diode CR14 open or current limit amplifier U3 defective. |
| Poor load or line regulation | Check reference voltages (12.4V, 6.2V, and 7.5V) | a. Voltages incorrect (beyond $\pm 10\%$ tolerance). Check reference supply as indicated in Table 5-3, Steps 2 and 3. b. Voltages correct (within $\pm 10\%$). Supply may be current limiting — read Paragraph 5-10. |
| Oscillation and/or poor load transient recovery time | ---- | a. Higher frequency oscillations (above 50kHz) can be caused by an open C13, C14, or C18. b. A defective output capacitor (C11) or feedback capacitor (C19) can cause oscillations in one of many frequency ranges. c. Oscillations occurring only in the current limiting mode, can be caused by an open C15 or C16. Oscillation near the current limiting crossover point are caused by an open CR15. |

Table 5-3. Low Output Voltage Troubleshooting

| STEP | ACTION | RESPONSE | PROBABLE CAUSE |
|------|--|---|--|
| 1 | Check input voltage to reference supply; voltage between test points 8 (+) and N should read $30 \pm 6\text{Vdc}$. | a. Normal voltage b. Abnormal | a. Proceed to Step 2. b. CR1 or CR2 open or shorted. TC1, T1 open. |
| 2 | Check +12.4V reference. Voltage between test points P (+) and +S should be $12.4 \pm 1.3\text{Vdc}$ | a. Normal voltage b. Abnormal | a. Proceed to Step 3. b. Q1 or R1 open. |
| 3 | Check +6.2V and -7.5V references. Voltage between test points R or N and +S should be $6.2 \pm 0.7\text{Vdc}$, or $7.5 \pm 0.8\text{Vdc}$, respectively. | a. Normal voltage b. Abnormal | a. Proceed to Step 4. b. Check applicable zener diode, VR1 or VR2. |
| 4 | Check raw dc input to main power supply. Voltage between test point F and +S are different for each model and are given in a table opposite the appropriate schematic. | a. Normal voltage b. Abnormal voltage (beyond $\pm 20\%$) | a. Proceed to Step 5. b. CR3—CR6 (or U4) open. C9 shorted or T1 open |
| 5 | To eliminate the current limit circuit as a possible source of the trouble, measure voltage drop across applicable OR-gate diode (CR14), Test points C to G. | a. T.P. C negative with respect to G (-1.8V). b. T.P. C positive with respect to G (0.7V). | a. Unit in Constant Voltage mode, proceed to Step 6. b. Unit in current limiting mode, proceed to current limit troubleshooting, Table 5-5. ————— CAUTION ————— Do not perform Steps 6 and 7 if unit is in the current limit mode. If the output is shorted, performing Steps 6 and 7 will damage the series regulator. |
| 6 | Check conduction capability of series regulator by shorting driver transistor Q3, emitter-to-collector. | a. Output voltage increases b. Output voltage remains low. | a. Proceed to Step 7. b. Series regulator transistor(s) Q4 (Q5) open. Wiring to heat sink open. |

Table 5-3. Low Output Voltage Troubleshooting (Continued)

| STEP | ACTION | RESPONSE | PROBABLE CAUSE |
|------|---|--|--|
| 7 | NOTE: Q3 not included on 62048A. To check series regulator, perform action of Step 7. Check conduction of drive Q3 by shorting collector of Q2 (T.P. D) to +S terminal | a. Output voltage increases. b. Output voltage remains low. | a. Proceed to Step 8. b. Driver transistor Q3 open. |
| 8 | Check conduction of Q2 by shorting T.P. D to +S. | a. Output voltage increases b. Output voltage remains low. | a. Proceed to Step 9. b. Driver Q2 open. |
| 9 | Check turn-up capability of U2 by shorting pin 2 of U2 to +S. | a. Output voltage increases b. Output voltage remains low. | a. U2 is good. Check for defective input circuit component; R5, R7, R8, R11, CR11, or CR12. b. Check for open CR13, or defective feedback capacitor C13 or C14. If these components are good, replace defective U2. |

Table 5-4. High Output Voltage Troubleshooting

| STEP | ACTION | RESPONSE | PROBABLE CAUSE |
|------|---|---|--|
| 1 | Check turn-off of series regulator by shorting base-to-emitter of Q4 (shortout R30). | a. Output voltage decreases. b. Output voltage remains high. | a. Proceed to Step 2. b. Series regulator transistor(s) Q4 (Q5) shorted. Protection diode (CR8 or U5) shorted. |
| 2 | Check turn-off of drivers Q2 and Q3 by shorting base of Q2 (T.P.G) to +S. | a. Output voltage decreases b. Output voltage remains high. | a. Proceed to Step 3. b. Driver transistor Q2 or Q3 shorted. C18 or C19 shorted. |
| 3 | Check turn-off capability of U2 by shorting summing point (at pad W1) of U2 to — output terminal. | a. Output voltage decreases b. Output voltage remains high | a. U2 is good. Check for defective input circuit component; R5, R7, or R8. b. Check VR1 for —7.5V bias. If OK, check for open CR13 or shorted C13, C14, CR11 or CR12. If these components are good, replace defective U2. |

Table 5-5. Current Limit Troubleshooting

| STEP | ACTION | RESPONSE | PROBABLE CAUSE |
|------|--|---|--|
| 1 | If unit is equipped with Option 011 or 104 crowbar, disconnect crowbar SCR by lifting one end of R13 or R14 (resistor in series with SCR) on crowbar P.C. board. If unit does not have crowbar option, proceed directly to Step 2. | a. Output voltage goes high. b. Output voltage goes to normal. c. Output voltage remains low. | a. Crowbar fired due to high output voltage condition — proceed to Table 5-4. b. Crowbar defective — proceed to Table 5-6. c. Internal short or current limit circuit defective — proceed to Step 2. |
| 2 | Remove input power and connect ohmmeter across + and — output terminals. | a. Resistance less than value of R19 (see schematic). b. Resistance more than value of R19. | a. Capacitor C11 or protection diode CR9 (U5) shorted. b. Proceed to Step 3. |
| 3 | Check for presence of -7.5V across Zener diode VR1. | a. Voltage incorrect b. Voltage correct | a. VR1 defective b. CR14 shorted, U3 defective. |

Table 5-6. Crowbar Troubleshooting (Option 011 or 104)

| SYMPTOM | PROBABLE CAUSE |
|---|---|
| Crowbar always on, won't reset | a. CR5 (or CR6) shorted. If shorted, check Q4 for open. |
| Crowbar won't trip | a. Q1 open or shorted. b. Q2 (or Q3) open or shorted. c. R45 (crowbar adjust) open. d. CR4 (if used) shorted. e. +23V bias missing. |
| Crowbar trips but won't latch (oscillates on and off) | a. CR3 (if used) open |
| Crowbar trip point shifts or is susceptible to external noise | a. VR1 defective b. R45 intermittent c. C1, C2 open |
| Crowbar circuit prevents supply from reaching proper voltage, but SCR is not fired. | a. Q4 shorted. |

covered under the symptom "Oscillation" in Table 5-2. Random frequency noise is most often caused by a defective reference diode, VR2. A defective I.C. (U1 or U2) can also cause this problem.

5-49 If a line frequency ripple problem exists, check the ripple at the dc input to the reference supply across test points B and N. It should be less than 600mV p-p. If it is significantly greater than 600mV, check C1, CR1, and CR2. If it is less than 600mV, check the ripple between test point R and +S (+6.2V). The ripple at T.P. R should be less than 1mV p-p. If it is greater than 1mV, check VR2, Q1, and U1, in that order.

5-50 If the ripple is not excessive in the reference supply, check the ripple across the main filter capacitor (T.P. F to +S). It should be less than 200mV p-p at no load or less than 3V p-p at full load. If the ripple here is significantly larger, check C9, CR3-CR6 (or U4), and C4, in that order.

5-51 Spikes occurring at a 120Hz rate can be caused by an open C4 (or C5) if included. Try repositioning the leads in the rectifier area (CR3-CR6, or U4) if the spike problem persists.

5-52 Crowbar Troubleshooting (Units with Option 011 or 104 Only)

5-53 The following table provides continued troubleshooting information for both option 011 and 104. Operating instructions, circuit descriptions and schematics for both crowbars are contained in the applicable Appendix; A or B.

5-54 REPAIR AND REPLACEMENT

5-55 Cover Removal

5-56 **A Suffix Supplies.** To remove the wrap-around cover on "A" series supplies, remove two screws each from the front and rear of the package and lift cover away from unit. If unit is equipped with an optional crowbar, sufficient lead length is provided so that the cover can be placed beside the unit.

5-57 **C and E Suffix Supplies.** To remove the covers for both the "C" and "E" series supplies, proceed as follows:

- a. On right side of package, remove two screws approximately 5 inches to rear of the front edge of package. This loosens top and bottom L-shaped covers.

- b. To remove top-front cover remove four screws on front of unit; one per corner.

- c. To remove bottom-rear cover, remove four screws at rear of unit; one per corner.

5-58 Main P.C. Board Removal

5-59 **A Suffix Boards.** To remove the main P.C. board in "A" series supplies, proceed as follows:

- a. Remove cover (previously described).
- b. Remove two screws about 1/2-inch from rear edge holding terminal strip bracket.
- c. Remove two screws about 3-inches from rear edge holding P.C. board.
- d. Push P.C. board toward bottom of unit until top edge clears top slot in side cover.
- e. Pull board from top slot then out of bottom slot and rotate for access to circuit side.
- f. Ensure that leads are not pinched when re-assembling.

5-60 **C and E Suffix Boards.** To remove P.C. board for these supplies, proceed as follows:

- a. Loosen right cover and remove top-front cover (previously described).
- b. Remove bottom-rear cover.
- c. Remove left side cover by removing two screws about 5 inches back from front edge and two screws holding terminal strip bracket.
- d. Board and series regulating transistor(s) are now exposed for servicing or removal.

5-61 Series Regulator Replacement

5-62 To remove and replace a series regulating transistor, proceed as follows:

- a. Remove covers (previously described).
- b. Remove collector screws and unsolder base and emitter leads.
- c. To replace transistor, follow the below re-assembly order, as viewed from bottom of heat sink: Collector screw, flat washer, shoulder washer, heat sink, silicon grease (Dow DC-3, HP 6040-0209, or HP 8500-0059), mica insulator, more silicon grease, transistor, electrical lug (on one collector screw), lock-washer and nut. (On "A" series transistors, the base and emitter pins have associated insulator bushings.)

5-63 Capacitor Replacement (A Suffix Supplies)

5-64 Due to space limitations in "A" series supplies, some of the filter and output capacitors (C9 and C11)

are secured with nylon cable ties. These ties must be cut to remove C9 or C11. Replacement capacitors include these ties when ordered from Hewlett-Packard. Cable ties can also be ordered separately. Both C9 and C11 require Panduit type SST-2, or HP 1400-0265, cable ties. The ties can be installed with a special tool, such as a Panduit GS-2B, or with a pair of long nose pliers.

5-65 To replace the capacitor, proceed as follows:

- a. Thread pointed end of tie through holes in P.C. board from top. Ensure that gripping teeth are on inside of loop being formed.
- b. Insert capacitor in proper position on board. Head of cable tie should face inside of unit.
- c. Tighten cable tie with tool or pliers. Cut excess about 1/4-inch from head.
- d. Solder and trim capacitor leads.

5-66 Crowbar Board Removal

5-67 **A Suffix Supplies.** To remove the crowbar board (optional) on "A" series supplies, first remove the cover. Next, remove one number six and one number eight screw holding the crowbar board. If the SCR is replaced, use the same silicon grease recommended for the series regulating transistor.

5-68 **C and E Suffix Supplies.** For "C" and "E" series supplies, the crowbar board is removed as follows:

- a. Loosen right side cover.
- b. Remove top-front cover.
- c. Remove one self-tapping screw from center of bottom-rear cover.
- d. Loosen other self-tapping screw and rotate board upward to gain access to components.
- e. To remove board, remove second self-tapping screw completely.
- f. If SCR is replaced, use silicon grease recommended previously for series regulator.

5-69 Semiconductor Replacement

5-70 Table 5-7 contains replacement data for the semiconductors used in the modular supplies described by this manual. When replacing a semiconductor, use a Hewlett-Packard part or an exact commercial replacement part, if applicable. In cases where neither of these parts are immediately available and a part is needed for emergency operation or troubleshooting verification, the first or second alternate part (see Table 5-7) can be tried with at least a 90% probability of success. Also, the user has the option of hand select-

ing the alternate part by using the device characteristics listed in Table 5-7.

5-71 Notice that these alternate replacements apply only to the HP modular power supplies and their use in any other Hewlett-Packard instrument is not authorized because of inclusion in this table.

5-72 Current Limit Adjustment

5-73 The current limiting point for the supply is factory set to $104 \pm 1\%$ of the current rating with the output voltage set at nominal. As described in Paragraph 3-8, the current limit may require readjustment at output voltages other than nominal. The current limit should also be checked and adjusted, if necessary, after replacement of R15, R17 (if used), R18, or R19. Proceed as follows to check and adjust the current limit:

- a. Connect setup shown in Figure 5-6.
- b. With R_L at maximum, set output voltage to desired value.
- c. Decrease R_L until current limit is reached (substantial increase in 120Hz ripple observed on scope). Reading on voltmeter is equivalent to current limit point.
- d. If current limit of Step c is not $104 \pm 1\%$ of maximum current rating, change current limit by first increasing R_L .
- e. Next, use insulated tool to increase current limit setting (turn R18 clockwise).
- f. Again decrease R_L until voltmeter reads value equivalent to $104 \pm 1\%$ of maximum output current.
- g. Decrease current limit setting (R18 ccw) until supply current limits (ripple increases on scope).

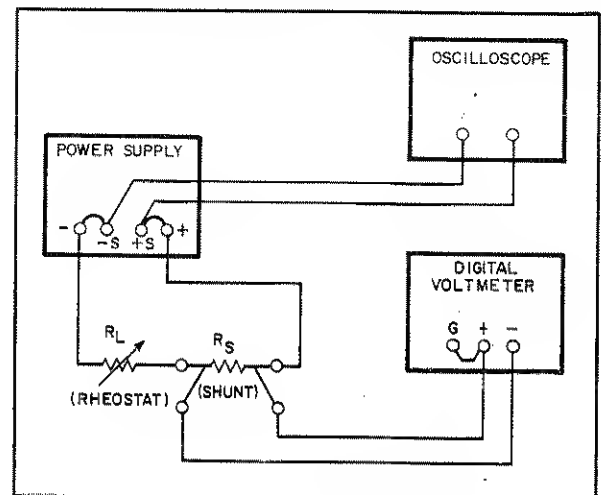


Figure 5-6. Current Limit Adjustment Setup

Table 5-7. Semiconductor Replacement Data

| REFERENCE DESIGNATOR | CHARACTERISTICS | HP PART NO. | EXACT COMMERCIAL REPLACEMENT | FIRST/ SECOND ALTERNATE |
|----------------------|---|-------------|------------------------------|---|
| U1, U2, U3 | BVCEO = 18V; I = 3mA; 0.5W, GAW = 84db; ft = 1MHz | 1B20-0223 | LM301AH Nat. Semi. | ---- |
| Q1 | BVCEO = 175V; I = 1A; 1W, GAW = 25 (min.); ft = 10MHz | 1B54-0095 | 40346 RCA | 2N3440/2N3439 |
| Q2 | BVCEO = 100V; I = 1A; 1W, GAW = 50 (min.); ft = 100MHz | 1B53-0037 | ---- | 2N3634/2N3636 |
| Q2 | BVCER = 70V; I = 0.7A; 1W, GAW = 35-200; ft = 60MHz | 1B53-0041 | ---- | 2N4036/2N4314 |
| Q2 | BVCEO = 40V; I = 0.4A, 0.31W, GAW = 90-180; ft = 90MHz | 1B53-0099 | ---- | 2N2907A/2N3906 |
| Q3 | BVCEO = 120V; I = 0.5A; 1W, GAW = 35 (min.); ft = 150MHz | 1B54-0271 | MM225B Moto. | 2N3500 |
| Q3 | BVCEO = 50V; I = 1A; 0.8W, ICBO = 10nA (max.); ft = 50MHz | 1B54-0244 | | 2N1711A/2N2102A |
| Q3, 4, 5 | BVCER = 80V; I = 15A; 175W, GAW = 50-90; ft = 500kHz | 1B54-0563 | ---- | 2N3055/2N503B |
| U4 | PIV = 100V; I = 15A; 150W, Isurge = 150A | 1906-0039 | SCPAI Semtech | 21PT10 Int. Rect. (Discrete Diodes) |
| U4 | PIV = 200V; I = 10A @ 100°C, 100W, Isurge = 100A | 1906-0041 | IN4436/T/F | 21PT10 Int. Rect. (Discrete Diodes) |
| U5 | PIV = 100V; I = 15A; 150W, Isurge = 150A | 1906-0040 | SCDAI Semtech | 21PT 10 Int. Rect. (Discrete Diodes) |
| VR1 | 7.5V, 0.4W | 1902-0064 | 1N5236B | 1N5236A |
| VR2 | 6.2V, 0.25W | 1902-1221 | 1N825 | 1N825A |
| CR1,2,3,4,5,6 | PIV = 200V; I = 1A; Irev. = 5μA | 1901-0327 | 1N5059 | ---- |
| CR3,4,5,6 | PIV = 200V; I = 3A; Irev. = 1mA | 1901-0416 | 1N4999 | ---- |

SECTION VI REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts. Table 6-4 lists parts in alpha-numeric order by reference designators and provides the following information:

- a. Reference Designators. Refer to Table 6-1.
- b. Description. Refer to Table 6-2 for abbreviations.
- c. Total Quantity (TQ). Given only the first time the part number is listed except in instruments containing many sub-modular assemblies, in which case the TQ appears the first time the part number is listed in each assembly.
- d. Manufacturer's Part Number or Type.
- e. Manufacturer's Federal Supply Code Number. Refer to Table 6-3 for manufacturer's name and address.
- f. Hewlett-Packard Part Number.
- g. Recommended Spare Parts Quantity (RS) for complete maintenance of one instrument during one year of isolated service.
- h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Mechanical and/or Miscellaneous. The former consists of parts belonging to and grouped by individual assemblies; the latter consists of all parts not immediately associated with an assembly.

6-3 ORDERING INFORMATION

6-4 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses). Specify the following information for each part: Model, complete serial number, and any Option or special modification (J) numbers of the instrument; Hewlett-Packard part number; circuit reference designator; and description. To order a part not listed in Table 6-4, give a complete description of the part, its function, and its location.

Table 6-1. Reference Designators

| | |
|-------------------------------|-------------------|
| A = assembly | E = miscellaneous |
| B = blower (fan) | electronic part |
| C = capacitor | F = fuse |
| CB = circuit breaker | J = jack, jumper |
| CR = diode | K = relay |
| DS = device, signaling (lamp) | L = inductor |
| | M = meter |

Table 6-1. Reference Designators (Continued)

| | |
|---------------------|-----------------------------------|
| P = plug | V = vacuum tube, |
| Q = transistor | neon bulb, |
| R = resistor | photocell, etc. |
| S = switch | VR = zener diode |
| T = transformer | X = socket |
| TB = terminal block | Z = integrated circuit or network |
| TS = thermal switch | |

Table 6-2. Description Abbreviations

| | |
|----------------------------------|----------------------------------|
| A = ampere | mfr = manufacturer |
| ac = alternating current | mod. = modular or modified |
| assy. = assembly | mtg = mounting |
| bd = board | n = nano = 10^{-9} |
| bkt = bracket | NC = normally closed |
| °C = degree Centigrade | NO = normally open |
| cd = card | NP = nickel-plated |
| coef = coefficient | Ω = ohm |
| comp = composition | obd = order by description |
| CRT = cathode-ray tube | OD = outside diameter |
| CT = center-tapped | p = pico = 10^{-12} |
| dc = direct current | P.C. = printed circuit |
| DPDT = double pole, double throw | pot. = potentiometer |
| DPST = double pole, single throw | p-p = peak-to-peak |
| elect = electrolytic | ppm = parts per million |
| encap = encapsulated | pvr = peak reverse voltage |
| F = farad | rect = rectifier |
| °F = degree Fahrenheit | rms = root mean square |
| fxd = fixed | Si = silicon |
| Ge = germanium | SPDT = single pole, double throw |
| H = Henry | SPST = single pole, single throw |
| Hz = Hertz | SS = small signal |
| IC = integrated circuit | T = slow-blow |
| ID = inside diameter | tan. = tantalum |
| incnd = incandescent | Ti = titanium |
| k = kilo = 10^3 | V = volt |
| m = milli = 10^{-3} | var = variable |
| M = mega = 10^6 | ww = wirewound |
| μ = micro = 10^{-6} | W = Watt |
| met. = metal | |

Table 6-3. Code List of Manufacturers

| CODE | MANUFACTURER | ADDRESS | CODE | MANUFACTURER | ADDRESS |
|-------|---|-----------------------|-------|--------------------------------------|-----------------------|
| 00629 | EBY Sales Co., Inc. | Jamaica, N.Y. | 07137 | Transistor Electronics Corp. | Minneapolis, Minn. |
| 00656 | Aerovox Corp. | New Bedford, Mass. | 07138 | Westinghouse Electric Corp. | Elmira, N.Y. |
| 00853 | Sangamo Electric Co. | | 07263 | Fairchild Camera and Instrument | |
| | S. Carolina Div. | Pickens, S.C. | | | Mountain View, Calif. |
| 01121 | Allen Bradley Co. | Milwaukee, Wis. | 07387 | Birtcher Corp., The | Los Angeles, Calif. |
| 01255 | Litton Ind. | Beverly Hills, Calif. | 07397 | Sylvania Electric Prod. Inc. | |
| 01281 | TRW Semiconductors, Inc. | Lawndale, Calif. | | | Mountainview, Calif. |
| 01295 | Texas Instruments, Inc. | Dallas, Texas | 07716 | IRC Div. of TRW Inc. | Burlington, Iowa |
| 01686 | RCL Electronics, Inc. | Manchester, N.H. | 07910 | Continental Device Corp. | |
| 01930 | Amerock Corp. | Rockford, Ill. | | | Hawthorne, Calif. |
| 02107 | Sparta Mfg. Co. | Dover, Ohio | 07933 | Raytheon Co. Components Div. | |
| 02114 | Ferroxcube Corp. | Saugerties, N.Y. | | | Mountain View, Calif. |
| 02606 | Fenwal Laboratories | Morton Grove, Ill. | 08484 | Breeze Corporations, Inc. | Union, N.J. |
| 02660 | Amphenol Corp. | Broadview, Ill. | 08530 | Reliance Mica Corp. | Brooklyn, N.Y. |
| 02735 | Radio Corp. of America, Solid State and | | 08717 | Sloan Company, The | Sun Valley, Calif. |
| | Receiving Tube Div. | Somerville, N.J. | 08730 | Vemaline Products Co. Inc. | |
| 03508 | G.E. Semiconductor Products Dept. | | | | Wyckoff, N.J. |
| | | Syracuse, N.Y. | 08806 | General Elect. Co. Miniature | |
| 03797 | Eldema Corp. | Compton, Calif. | | Lamp Dept. | Cleveland, Ohio |
| 03877 | Transitron Electronic Corp. | | 08863 | Nylomatic Corp. | Norrisville, Pa. |
| | | Wakefield, Mass. | 08919 | RCH Supply Co. | Vernon, Calif. |
| 03888 | Pyrofilm Resistor Co., Inc. | | 09021 | Airco Speer Electronic Components | |
| | | Cedar Knolls, N.J. | | | Bradford, Pa. |
| 04009 | Arrow, Hart and Hegeman Electric Co. | | 09182 | *Hewlett-Packard Co. New Jersey Div. | |
| | | Hartford, Conn. | | | Rockaway, N.J. |
| 04072 | ADC Electronics, Inc. | Harbor City, Calif. | 09213 | General Elect. Co. Semiconductor | |
| 04213 | Caddell & Burns Mfg. Co. Inc. | | | Prod. Dept. | Buffalo, N.Y. |
| | | Mineola, N.Y. | 09214 | General Elect. Co. Semiconductor | |
| 04404 | *Hewlett-Packard Co. Palo Alto Div. | | | Prod. Dept. | Auburn, N.Y. |
| | | Palo Alto, Calif. | 09353 | C & K Components Inc. | Newton, Mass. |
| 04713 | Motorola Semiconductor Prod. Inc. | | 09922 | Burndy Corp. | Norwalk, Conn. |
| | | Phoenix, Arizona | 11115 | Wagner Electric Corp. | |
| 05277 | Westinghouse Electric Corp. | | | Tung-Sol Div. | Bloomfield, N.J. |
| | Semiconductor Dept. | Youngwood, Pa. | 11236 | CTS of Berne, Inc. | Berne, Ind. |
| 05347 | Ultronix, Inc. | Grand Junction, Colo. | 11237 | Chicago Telephone of Cal. Inc. | |
| 05820 | Wakefield Engr. Inc. | Wakefield, Mass. | | | So. Pasadena, Calif. |
| 06001 | General Elect. Co. Electronic | | 11502 | IRC Div. of TRW Inc. | Boone, N.C. |
| | Capacitor & Battery Dept. | Irmo, S.C. | 11711 | General Instrument Corp. | Newark, N.J. |
| 06004 | Bassik Div. Stewart-Warner Corp. | | 12136 | Philadelphia Handle Co. | Camden, N.J. |
| | | Bridgeport, Conn. | 12615 | U.S. Terminals, Inc. | Cincinnati, Ohio |
| 06486 | IRC Div. of TRW Inc. | | 12617 | Hamlin Inc. | Lake Mills, Wisconsin |
| | Semiconductor Plant | Lynn, Mass. | 12697 | Clarostat Mfg. Co. Inc. | Dover, N.H. |
| 06540 | Amatom Electronic Hardware Co. Inc. | | 13103 | Thermalloy Co. | Dallas, Texas |
| | | New Rochelle, N.Y. | 14493 | *Hewlett-Packard Co. | Loveland, Colo. |
| 06555 | Beede Electrical Instrument Co. | | 14655 | Cornell-Dubilier Electronics Div. | |
| | | Penacook, N.H. | | Federal Pacific Electric Co. | |
| 06666 | General Devices Co. | Indianapolis, Ind. | | | Newark, N.J. |
| 06751 | Semoor Div. Components, Inc. | | 14936 | General Instrument Corp. Semicon- | |
| | | Phoenix, Arizona | | ductor Prod. Group | Hicksville, N.Y. |
| 06776 | Robinson Nugent, Inc. | New Albany, N.Y. | 15801 | Fenwal Elect. | Framingham, Mass. |
| 06812 | Torrington Mfg. Co. | Van Nuys, Calif. | 16299 | Corning Glass Works | Raleigh, N.C. |

* Use Code 28480 assigned to Hewlett-Packard Co., Palo Alto, California

Table 6-3. Code List of Manufacturers (Continued)

| CODE NO. | MANUFACTURER | ADDRESS | CODE NO. | MANUFACTURER | ADDRESS |
|----------|--|-------------------------------------|----------|--|-----------------------------------|
| 16758 | Delco Radio Div. of General Motors Corp. | Kokomo, Ind. | 70563 | Amperite Co. Inc. | Union City, N.J. |
| 17545 | Atlantic Semiconductors, Inc. | Asbury Park, N.J. | 70901 | Beemer Engrg. Co. | Fort Washington, Pa. |
| 17803 | Fairchild Camera and Instrument Corp | Semiconductor Div. Transducer Plant | 70903 | Belden Corp. | Chicago, Ill. |
| 17870 | Daven Div. Thomas A. Edison Industries | Mountain View, Calif. | 71218 | Bud Radio, Inc. | Willoughby, Ohio |
| 18324 | Signetics Corp. | Sunnyvale, Calif. | 71279 | Cambridge Thermionic Corp. | Cambridge, Mass. |
| 19315 | Bendix Corp. The Navigation and Control Div. | Teterboro, N.J. | 71400 | Bussmann Mfg. Div. of McGraw & Edison Co. | St. Louis, Mo. |
| 19701 | Electra/Midland Corp. | Mineral Wells, Texas | 71450 | CTS Corp. | Elkhart, Ind. |
| 21520 | Fansteel Metallurgical Corp. | No. Chicago, Ill. | 71468 | I. T. T. Cannon Electric Inc. | Los Angeles, Calif. |
| 22229 | Union Carbide Corp. Electronics Div. | Mountain View, Calif. | 71590 | Globe-Union Inc. | Centralab Div. Milwaukee, Wis. |
| 22753 | UID Electronics Corp. | Hollywood, Fla. | 71700 | General Cable Corp. Cornish | Wire Co. Div. Williamstown, Mass. |
| 23936 | Pamotor, Inc. | Pampa, Texas | 71707 | Coto Coil Co. Inc. | Providence, R. I. |
| 24446 | General Electric Co. | Schenectady, N.Y. | 71744 | Chicago Miniature Lamp Works | Chicago, Ill. |
| 24455 | General Electric Co. Lamp Div. of Consumer Prod. Group | Nela Park, Cleveland, Ohio | 71785 | Cinch Mfg. Co. and Howard | 8. Jones Div. Chicago, Ill. |
| 24655 | General Radio Co. | West Concord, Mass. | 71984 | Dow Corning Corp. | Midland, Mich. |
| 24681 | LTV Electrosystems Inc Memcor/Components Operations | Huntington, Ind. | 72136 | Electro Motive Mfg. Co. Inc. | Willimantic, Conn. |
| 26982 | Dynacool Mfg. Co. Inc. | Saugerties, N.Y. | 72619 | Dialight Corp. | Brooklyn, N.Y. |
| 27014 | National Semiconductor Corp. | Santa Clara, Calif. | 72699 | General Instrument Corp. | Newark, N.J. |
| 28480 | Hewlett-Packard Co. | Palo Alto, Calif. | 72765 | Drake Mfg. Co. | Harwood Heights, Ill. |
| 28520 | Heyman Mfg. Co. | Kenilworth, N.J. | 72962 | Elastic Stop Nut Div. of | Amerace Esna Corp. Union, N.J. |
| 28875 | IMC Magnetics Corp. | New Hampshire Div. Rochester, N.H. | 72982 | Erie Technological Products Inc. | Erie, Pa. |
| 31514 | SAE Advance Packaging, Inc. | Santa Ana, Calif. | 73096 | Hart Mfg. Co. | Hartford, Conn. |
| 31827 | Budwig Mfg. Co. | Ramona, Calif. | 73138 | Beckman Instruments Inc. | Helipot Div. Fullerton, Calif. |
| 33173 | G. E. Co. Tube Dept. | Owensboro, Ky. | 73168 | Fenwal, Inc. | Ashland, Mass. |
| 35434 | Lectrohm, Inc. | Chicago, Ill. | 73293 | Hughes Aircraft Co. Electron Dynamics Div. | Torrance, Calif. |
| 37942 | P. R. Mallory & Co. Inc. | Indianapolis, Ind. | 73445 | Amperex Electronic Corp. | Hicksville, N.Y. |
| 42190 | Muter Co. | Chicago, Ill. | 73506 | Bradley Semiconductor Corp. | New Haven, Conn. |
| 43334 | New Departure-Hyatt Bearings Div. | General Motors Corp. Sandusky, Ohio | 73559 | Carling Electric, Inc. | Hartford, Conn. |
| 44655 | Ohmite Manufacturing Co. | Skokie, Ill. | 73734 | Federal Screw Products, Inc. | Chicago, Ill. |
| 46384 | Penn Engr. and Mfg. Corp. | Doylestown, Pa. | 74193 | Heinemann Electric Co. | Trenton, N.J. |
| 47904 | Polaroid Corp. | Cambridge, Mass. | 74545 | Hubbell Harvey Inc. | Bridgeport, Conn. |
| 49956 | Raytheon Co. | Lexington, Mass. | 74868 | Amphenol Corp. Amphenol RF Div. | Danbury, Conn. |
| 55026 | Simpson Electric Co. Div. of American | Gage and Machine Co. Chicago, Ill. | 74970 | E. F. Johnson Co. | Waseca, Minn. |
| 56289 | Sprague Electric Co. | North Adams, Mass. | 75042 | IRC Div. of TRW, Inc. | Philadelphia, Pa. |
| 58474 | Superior Electric Co. | Bristol, Conn. | 75183 | *Howard B. Jones Div. of Cinch | Mfg. Corp. New York, N.Y. |
| 58849 | Syntron Div. of FMC Corp. | Homer City, Pa. | 75376 | Kurz and Kasch, Inc. | Dayton, Ohio |
| 59730 | Thomas and Betts Co. | Philadelphia, Pa. | 75382 | Kilka Electric Corp. | Mt. Vernon, N.Y. |
| 61637 | Union Carbide Corp. | New York, N.Y. | 75915 | Littlefuse, Inc. | Des Plaines, Ill. |
| 63743 | Ward Leonard Electric Co. | Mt. Vernon, N.Y. | 76381 | Minnesota Mining and Mfg. Co. | St. Paul, Minn. |
| | | | 76385 | Minor Rubber Co. Inc. | Bloomfield, N.J. |
| | | | 76487 | James Millen Mfg. Co. Inc. | Malden, Mass. |
| | | | 76493 | J. W. Miller Co. | Compton, Calif. |

*Use Code 71785 assigned to Cinch Mfg. Co., Chicago, Ill.

Table 6-3. Code List of Manufacturers (Continued)

| CODE NO. | MANUFACTURER | ADDRESS |
|----------|--|--------------------------|
| 76530 | Cinch | City of Industry, Calif. |
| 76854 | Oak Mfg. Co. Div. of Oak | |
| 77068 | Electro/Netics Corp. | Crystal Lake, Ill. |
| | Bendix Corp., Electrodynamics Div. | |
| | | No. Hollywood, Calif. |
| 77122 | Palnut Co. | Mountainside, N. J. |
| 77147 | Patton-MacGuyer Co. | Providence, R. I. |
| 77221 | Phaotron Instrument and Electronic Co. | |
| | | South Pasadena, Calif. |
| 77252 | Philadelphia Steel and Wire Corp. | |
| | | Philadelphia, Pa. |
| 77342 | American Machine and Foundry Co. | |
| | Potter and Brumfield Div. | Princeton, Ind. |
| 77630 | TRW Electronic Components Div. | |
| | | Camden, N. J. |
| 77764 | Resistance Products Co. | Harrisburg, Pa. |
| 78189 | Illinois Tool Works Inc. Shakeproof Div. | |
| | | Elgin, Ill. |
| 78452 | Everlock Chicago, Inc. | Chicago, Ill. |
| 78488 | Stackpole Carbon Co. | St. Marys, Pa. |
| 78526 | Stanwyck Winding Div. | San Fernando |
| | Electric Mfg. Co. Inc. | Newburgh, N. Y. |
| 78553 | Tinnerman Products, Inc. | Cleveland, Ohio |
| 78584 | Stewart Stamping Corp. | Yonkers, N. Y. |
| 79136 | Waldes Kohinoor, Inc. | L. I. C., N. Y. |
| 79307 | Whitehead Metals Inc. | New York, N. Y. |
| 79727 | Continental-Wirt Electronics Corp. | |
| | | Philadelphia, Pa. |
| 79963 | Zierick Mfg. Co. | Mt. Kisco, N. Y. |
| 80031 | Mepco Div. of Sessions Clock Co. | |
| | | Morristown, N. J. |
| 80294 | Bourms, Inc. | Riverside, Calif. |
| 81042 | Howard Industries Div. of Msl Ind. Inc. | |
| | | Racine, Wisc. |
| 81073 | Grayhill, Inc. | La Grange, Ill. |
| 81483 | International Rectifier Corp. | |
| | | El Segundo, Calif. |
| 81751 | Columbus Electronics Corp. | Yonkers, N. Y. |
| 82099 | Goodyear Sundries & Mechanical Co. Inc. | |
| | | New York, N. Y. |
| 82142 | Airco Speer Electronic Components | |
| | | Du Bois, Pa. |
| 82219 | Sylvania Electric Products Inc. | |
| | Electronic Tube Div. Receiving | |
| | Tube Operations | Emporium, Pa. |
| 82389 | Switchcraft, Inc. | Chicago, Ill. |
| 82647 | Metals and Controls Inc. Control | |
| | Products Group | Attleboro, Mass. |
| 82866 | Research Products Corp. | Madison, Wis. |
| 82877 | Rotron Inc. | Woodstock, N. Y. |
| 82893 | Vector Electronic Co. | Glendale, Calif. |
| 83058 | Carr Fastener Co. | Cambridge, Mass. |
| 83186 | Victory Engineering Corp. | |
| | | Springfield, N. J. |
| 83298 | Bendix Corp. Electric Power Div. | |
| | | Eatontown, N. J. |
| 83330 | Herman H. Smith, Inc. | Brooklyn, N. Y. |
| 83385 | Central Screw Co. | Chicago, Ill. |
| 83501 | Gavitt Wire and Cable Div. of | |
| | Amerace Esna Corp. | Brookfield, Mass. |

| CODE NO. | MANUFACTURER | ADDRESS |
|----------|---|-----------------------|
| 83508 | Grant Pulley and Hardware Co. | |
| | | West Nyack, N. Y. |
| 83594 | Burroughs Corp. Electronic | |
| | Components Div. | Plainfield, N. J. |
| 83835 | U. S. Radium Corp. | Morristown, N. J. |
| 83877 | Yardeny Laboratories, Inc. | |
| | | New York, N. Y. |
| 84171 | Arco Electronics, Inc. | Great Neck, N. Y. |
| 84411 | TRW Capacitor Div. | Ogallala, Neb. |
| 86684 | RCA Corp. Electronic Components | |
| | | Harrison, N. J. |
| 86838 | Rummel Fibre Co. | Newark, N. J. |
| 87034 | Marco & Oak Industries a Div. of Oak | |
| | Electro/netics Corp. | Anaheim, Calif. |
| 87216 | Philco Corp. Lansdale Div. | Lansdale, Pa. |
| 87585 | Stockwell Rubber Co. Inc. | |
| | | Philadelphia, Pa. |
| 87929 | Tower-Olschan Corp. | Bridgeport, Conn. |
| 88140 | Cutler-Hammer Inc. Power Distribution | |
| | and Control Div. Lincoln Plant | |
| | | Lincoln, Ill. |
| 88245 | Litton Precision Products Inc. USECO | |
| | Div. Litton Industries | Van Nuys, Calif. |
| 90634 | Gulton Industries Inc. | Metuchen, N. J. |
| 90763 | United-Car Inc. | Chicago, Ill. |
| 91345 | Miller Dial and Nameplate Co. | |
| | | El Monte, Calif. |
| 91418 | Radio Materials Co. | Chicago, Ill. |
| 91506 | Augat, Inc. | Attleboro, Mass. |
| 91637 | Dale Electronics, Inc. | Columbus, Neb. |
| 91662 | Elco Corp. | Willow Grove, Pa. |
| 91929 | Honeywell Inc. Div. Micro Switch | |
| | | Freeport, Ill. |
| 92825 | Whitso, Inc. | Schiller Pk., Ill. |
| 93332 | Sylvania Electric Prod. Inc. Semi- | |
| | conductor Prod. Div. | Woburn, Mass. |
| 93410 | Essex Wire Corp. Stemco | |
| | Controls Div. | Mansfield, Ohio |
| 94144 | Raytheon Co. Components Div. | |
| | Ind. Components Oper. | Quincy, Mass. |
| 94154 | Wagner Electric Corp. | |
| | Tung-Sol Div. | Livingston, N. J. |
| 94222 | Southco Inc. | Lester, Pa. |
| 95263 | Leecraft Mfg. Co. Inc. | L. I. C., N. Y. |
| 95354 | Methode Mfg. Co. | Rolling Meadows, Ill. |
| 95712 | Bendix Corp. Microwave | |
| | Devices Div. | Franklin, Ind. |
| 95987 | Weckesser Co. Inc. | Chicago, Ill. |
| 96791 | Amphenol Corp. Amphenol | |
| | Controls Div. | Janesville, Wis. |
| 97464 | Industrial Retaining Ring Co. | |
| | | Irvington, N. J. |
| 97702 | IMC Magnetics Corp. Eastern Div. | |
| | | Westbury, N. Y. |
| 98291 | Sealectro Corp. | Mamaroneck, N. Y. |
| 98410 | ETC Inc. | Cleveland, Ohio |
| 98978 | International Electronic Research Corp. | |
| | | Burbank, Calif. |
| 99934 | Renbrandt, Inc. | Boston, Mass. |

Table 6-4. Replaceable Parts

| REF. DESIG. | DESCRIPTION | TQ | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|--------------------------------------|---------------------------------|----|----------------|-----------|-------------|----|
| A-SERIES (62003A thru 62048A) | | | | | | |
| | Main Power Supply Board | | | | | |
| C1 | fxd, elect. 300 μ F 40Vdc | 1 | 34D307G040GJ2 | 56289 | 0180-1805 | 1 |
| C2 | fxd, mica 390pF 300Vdc | 1 | | 28480 | 0140-0200 | 1 |
| C3 | fxd, mylar .47 μ F 25Vdc | 2 | | 28480 | 0160-0174 | 1 |
| C4 | fxd, ceramic .05 μ F 400Vdc | 1 | | 28480 | 0150-0052 | 1 |
| C9 | | 1 | | | | |
| 62003A thru 62010A | fxd, elect. 6000 μ F 25Vdc | | | 28480 | 0180-2520 | |
| 62012A thru 62028A | fxd, elect. 3000 μ F 50VDC | | | 28480 | 0180-2510 | |
| 62048A | fxd, elect. 1500 μ F 100Vdc | | | 28480 | 0180-2521 | |
| C11 | | 1 | | | | 1 |
| 62003A thru 62024A | fxd, elect. 1400 μ F 30Vdc | | | 28480 | 0180-1860 | |
| 62028A, 62048A | fxd, elect. 490 μ F 65Vdc | | | 28480 | 0180-1856 | |
| C12 | | | | | | 1 |
| 62003A thru 62028A | fxd, tantalum 4.7 μ F 35Vdc | | 150D475X903582 | 56289 | 0180-0100 | |
| 62048A | fxd, tantalum 5 μ F 65Vdc | | | 28480 | 0180-1836 | 1 |
| C13 | fxd, mylar .01 μ F 200Vdc | 1 | 192P10392 | 56289 | 0160-0161 | 1 |
| C14 | fxd, mica 10pF 300Vdc | 1 | RDM15C10053C | 00853 | 0160-2197 | 1 |
| C15 | fxd, mica .47 μ F 25Vdc | | | 28480 | 0160-0174 | |
| C16 | fxd, mica 30pF 300Vdc | 1 | RDM15E300J3C | 00853 | 0160-2199 | 1 |
| CR1,2 | Rectifier Si 200V 1A | 4 | IN5059 | 28480 | 1901-0327 | 4 |
| CR3-6 | | 4 | | | | 4 |
| 62003A thru 62006A | Diode Si 200V 3A | | IN4999 | 28480 | 1901-0416 | |
| 62010A thru 62048A | Diode Si 200V 1A | | IN5059 | 28480 | 1901-0327 | |
| CR8,9 | Rectifier Si 200V 1A | | IN5059 | 28480 | 1901-0327 | |
| CR11-14 | Diode Si 250mW 200V | 4 | IN4858 | 28480 | 1901-0033 | 4 |
| CR15 | Stabistor 400mW 10V | 1 | | 28480 | 1901-0460 | 1 |
| Q1 | SS NPN Si | 1 | 40346 | 02735 | 1854-0095 | 1 |
| Q2 | SS PNP Si | 1 | | 28480 | 1853-0099 | 1 |
| Q3 | SS NPN Si | 1 | MM2258 | 04713 | 1854-0271 | 1 |
| R1 | fxd, comp 1.5k 5% 1/2W | 1 | E8-1525 | 01121 | 0686-1525 | 1 |
| R2,3 | fxd, met film 6.2k 1% 1/8W | 2 | Type CEA T-O | 07716 | 0698-5087 | 1 |
| R4 | fxd, met film 750 1% 1/8W | 1 | Type CEA T-O | 07716 | 0757-0420 | 1 |
| R5 | fxd, ww 5.9k 1% 2/3W | 1 | | 28480 | 0811-1978 | 1 |
| R6 | | 1 | | | | 1 |
| 62003A | fxd, ww 3.6k 5% 3W | | 242E3625 | 56289 | 0811-1810 | |
| 62004A | fxd, ww 4.7k 5% 3W | | | 28480 | 0811-1812 | |
| 62005A | fxd ww 6.8k 5% 3W | | 242E6825 | 56289 | 0811-0960 | |
| 62006A | fxd, ww 10k 5% 3W | | 242E1035 | 56289 | 0811-1816 | |
| 62010A thru 62048A | Not Used | | | | | |
| R8 | | 1 | | | | 1 |
| 62003A | fxd, ww 2100 1% 1W | | | 28480 | 0811-3187 | |
| 62004A | fxd, ww 2950 1% 1W | | | 28480 | 0811-3192 | |
| 62005A | fxd, ww 3800 1% 1W | | | 28480 | 0811-3195 | |
| 62006A | fxd, ww 4660 1% 1W | | | 28480 | 0811-3193 | |
| 62010A | fxd, ww 10,750 1% 3W | | | 28480 | 0811-3194 | |
| 62012A | fxd, ww 12,900 1% 3W | | | 28480 | 0811-3186 | |

| REF. DESIG. | DESCRIPTION | TQ | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|--------------------|------------------------------|----|---------------|--------------|----------------|----|
| 62015A | fxd, ww 16,100 1% 3W | | | 28480 | 08 11-3196 | |
| 62018A | fxd, ww 19,350 1% 3W | | | 28480 | 08 11-3190 | |
| 62024A | fxd, ww 25,800 1% 4W | | | 28480 | 08 11-3188 | |
| 62028A | fxd, ww 30,050 1% 4W | | | 28480 | 08 11-3191 | |
| 62048A | fxd, ww 51,550 1% 5W | | | 28480 | 08 11-3197 | |
| R10 | | 1 | | | | 1 |
| 62003A thru 62006A | fxd, comp 1k 5% 1/2W | | EB-1025 | 01121 | 0686-1025 | |
| 62010A thru 62015A | fxd, comp 3.9k 5% 1/2W | | EB-3925 | 01121 | 0686-3925 | |
| 62018A | fxd, comp 4.3k 5% 1/2W | | EB-4325 | 01121 | 0686-4325 | |
| 62024A | fxd, comp 5.6k 5% 1/2W | | EB-5625 | 01121 | 0686-5625 | |
| 62028A | fxd, comp 7.5k 5% 1/2W | | EB-7525 | 01121 | 0686-7525 | |
| 62048A | fxd, comp 22 5% 1/2W | | EB-2205 | 01121 | 0686-2205 | |
| R11 | fxd, ww 1k 5% 3W | 1 | 242E1025 | 56289 | 08 13-0001 | 1 |
| R12 | fxd, comp 7.5k 5% 1/2W | 1 | EB-7525 | 01121 | 0686-7525 | 1 |
| R13 | fxd, comp 560 5% 1/2 | 2 | EB-5615 | 01121 | 0686-5615 | 1 |
| R15 | (Current Sampling) | 1 | | | | 1 |
| 62003A thru 62005A | fxd, ww 0.125 10% 3W | | Type CW2B-1 | 91637 | 08 11-1828 | |
| 62006A thru 62015A | fxd, ww 0.15 5% 3W | | | 28480 | 08 12-0045 | |
| 62018A | fxd, ww 0.25 10% 3W | | Type CW2B-1 | 91637 | 08 11-1829 | |
| 62024A, 62028A | fxd, ww 0.33 5% 2W | | Type BWH | 07716 | 08 12-0066 | |
| 62048A | fxd, ww 0.51 5% 2W | | Type BWH | 07716 | 08 11-0929 | |
| R18 | (Current Limit Adjust) | 1 | | | | 1 |
| 62003A thru 62006A | var. ww 5 20% 1.5W | | Type 110-F4 | 11236 | 2100-1821 | |
| 62010 thru 62048A | var. ww 10 20% 1.5W | | Type 110-F4 | 11236 | 2100-1822 | |
| R19 | | 1 | | | | 1 |
| 62003A thru 62006A | fxd, met. oxide 30 5% 2W | | | 28480 | 0764-0041 | |
| 62010A thru 62018A | fxd, met. oxide 270 5% 2W | | Type C-425 | 16299 | 0698-3629 | |
| 62024A, 62028A | fxd, met. oxide 560 5% 2W | | Type C-425 | 16299 | 0764-0015 | |
| 62048A | fxd, met. oxide 1.1k 5% 3W | | Type 242E | 56289 | 08 11-2878 | |
| R20 | | 1 | | | | 1 |
| 62003A thru 62005A | | | | | | |
| 62018A thru 62048A | fxd, met. film 139 1% 1/8W | | Type CEA T-0 | 07716 | 0698-4099 | |
| 62006A thru 62012A | fxd, met. film 150 1% 1/8W | | Type CEA T-0 | 07716 | 0757-0284 | |
| 62015A | fxd, met. film 107 1% 1/8W | | | 28480 | 0698-4405 | |
| R21 | fxd, met. film 68.1k 1% 1/8W | 1 | Type CEA T-0 | 07716 | 0757-0461 | 1 |
| R22 | fxd, comp 100 5% 1/2W | 3 | EB-1015 | 01121 | 0686-1015 | 1 |
| R23 | fxd, comp 560 5% 1/2W | | EB-5615 | 01121 | 0686-5615 | |
| R25 | fxd, comp 1.3k 5% 1/2W | 1 | EB-1325 | 01121 | 0686-1325 | 1 |
| R26 | fxd, comp 270 5% 1/2W | 1 | EB-2715 | 01121 | 0686-2715 | 1 |
| R27 | | 1 | | | | 1 |
| 62003A thru 62028A | fxd, comp 12 5% 1/2W | | EB-1205 | 01121 | 0686-1205 | |
| 62048A | Not Used | | | | | |
| R28 | | 1 | | | | 1 |
| 62003A thru 62028A | fxd, comp 1k 5% 1/2W | 1 | EB-1025 | 01121 | 0686-1025 | |
| 62048A | Not Used | | | | | |
| R29 | | 1 | | | | 1 |
| 62003A | fxd, met. oxide 30 5% 2W | | Type C-425 | 16299 | 0764-0041 | |
| 62004A, 62005A | fxd, met. oxide 56 5% 2W | | Type C-425 | 16299 | 0764-0013 | |
| 62006A | fxd, met. oxide 100 5% 2W | | Type C-425 | 16299 | 0698-3260 | |

| REF. DESIG. | DESCRIPTION | TQ | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|--------------------|---|----|---------------|-----------|-------------|----|
| 62010A | fxd, met. oxide 200 5% 2W | | | 28480 | 0698-3627 | |
| 62012A | fxd, met. oxide 270 5% 2W | | Type C-425 | 16299 | 0698-3629 | |
| 62015A | fxd, met. oxide 390 5% 2W | | Type C-425 | 16299 | 0698-3633 | |
| 62018A | fxd, met. oxide 510 5% 2W | | Type C-425 | 16299 | 0698-0030 | |
| 62024A | fxd, met. oxide 680 5% 2W | | Type C-425 | 16299 | 0698-3635 | |
| 62028A | fxd, met. oxide 820 5% 2W | | Type C-425 | 16299 | 0098-3637 | |
| 62048A | fxd, met. oxide 2k 5% 3W | | | 28480 | 0811-1806 | |
| R30 | fxd, comp 75 5% 1/2W | 1 | E8-7505 | 01121 | 0686-7505 | 1 |
| R31 | | 1 | | | | 1 |
| 62003A thru 62010A | fxd, comp 1.5k 5% 1W | | 68-1525 | 01121 | 0689-1525 | |
| 62012A thru 62018A | fxd, comp 3k 5% 1W | | 68-3025 | 01121 | 0689-3025 | |
| 62024A, 62028A | fxd, comp 5.1k 5% 1W | | 68-5125 | 01121 | 0689-5125 | |
| 62048A | fxd, comp 5.6k 3% 3W | | RS28-95 | 91637 | 0812-0091 | |
| R32, 33 | fxd, comp 100 5% 1/2W | | EB-1015 | 01121 | 0686-1015 | |
| U1-3 | Operational Amplifier | 3 | LM301A | 07014 | 1820-0223 | 1 |
| VR1 | Diode, zener 7.5V 400mW | 1 | | 28480 | 1902-0064 | 1 |
| VR2 | Diode, zener 6.2V 250mW | 1 | | 28480 | 1902-1221 | 1 |
| | Chassis Electrical | | | | | |
| F1 | | 1 | | | | 5 |
| 62003A thru 62006A | Fuse, 0.5A 250V | | 312.500 | 75915 | 2110-0012 | |
| 62010A thru 62048A | Fuse, 0.75A 250V | | | 28480 | 2110-0063 | |
| O4 | Power NPN Si | 1 | | 28480 | 1854-0563 | 1 |
| R7 | (Voltage Adjust) | 1 | | | | 1 |
| 62003A thru 62006A | var. ww 2700 5% 2W | | | 28480 | 2100-3255 | |
| 62010A thru 62048A | var. ww 1800 5% 2W | | | 28480 | 2100-3254 | |
| T1 | | 1 | | | | 1 |
| 62003A thru 62005A | Power Transformer | | | 28480 | 5080-7193 | |
| 62006A thru 62015A | Power Transformer | | | 28480 | 5080-7194 | |
| 62018A thru 62028A | Power Transformer | | | 28480 | 5080-7195 | |
| 62048A | Power Transformer | | | 28480 | 62048-80091 | |
| T81 | Terminal Block (Rear), 7-Term. | 1 | | 28480 | 0360-1766 | |
| TC1 | Thermal Switch, open 220 \pm 6°F, close 195 \pm 8°F | 1 | | 28480 | 3103-0018 | 1 |
| | Mechanical | | | | | |
| | Wrap Around Cover | 1 | | 28480 | | |
| | 62003A | | | | 62003-60001 | |
| | 62004A | | | | 62004-60001 | |
| | 62005A | | | | 62005-60001 | |
| | 62006A | | | | 62006-60001 | |
| | 62010A | | | | 62010-60001 | |
| | 62012A | | | | 62012-60001 | |
| | 62015A | | | | 62015-60001 | |
| | 62018A | | | | 62018-60001 | |
| | 62024A | | | | 62024-60001 | |
| | 62028A | | | | 62028-60001 | |

| REF. DESIG. | DESCRIPTION | TQ | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|---|--|----|---------------|--------------|----------------|----|
| F1 62003A thru 62006A 62010A thru 62048 T1 62003A thru 62005A 62006A thru 62015A 62018A thru 62028A 62048A | 62048A | | | | 62048-60001 | |
| | Side Panel | 1 | | 28480 | 5020-8087 | |
| | Snap Bushing, Side Panel (Current Limit Adj.) | 1 | | 28480 | 0400-0064 | |
| | Terminal Block Jumper (TB1) | 2 | | 28480 | 0360-1784 | |
| | Terminal Block Cover (TB1) | 1 | | 28480 | 4040-0948 | |
| | Heat Sink (Q4) | 1 | | 28480 | 5000-9349 | |
| | Insulator, Mica (Q4) | 1 | 757-T0-3 | 08530 | 0340-0181 | |
| | Insulator, Transistor Pin (Q4) | 2 | | 28480 | 0340-0167 | |
| | Insulator, Shoulder Washer (Q4) | 2 | | 28480 | 2190-0490 | |
| | Fuseholder, F1 | 1 | 342014 | 75915 | 1400-0084 | |
| | Insulator, Fuseholder | 1 | 901-129 | 75915 | 1400-0090 | |
| | Bracket, Rear Chassis | 1 | | 28480 | 5000-9351 | |
| | Bracket, Volt. Adj. | 1 | | 28480 | 5000-9348 | |
| | Tie Wrap (C9 and C11) | 3 | | 28480 | 1400-0265 | |
| | Plug (Crowbar Adjust hole) | 1 | | 28480 | | |
| | Packing Carton | 1 | | 28480 | 9211-1197 | |
| | Floater Pad, Packing Carton | 1 | | 28480 | 9220-1411 | |
| | Floater Pad, Packing Carton | 1 | | 28480 | 9220-1414 | |
| | Floater Pad, Packing Carton | 1 | | 28480 | 9220-1415 | |
| | Option 101 (220V ac) | | | | | |
| | Option 102 (240V ac) | | | | | |
| | | 1 | | | | 5 |
| | Fuse, 0.3A 250V | | | 28480 | 2110-0067 | |
| | Fuse, 0.375A 250V | | | 28480 | 2110-0065 | |
| | Power Transformer (wired for 220V ac for option 101 or 240V ac for option 102) | | | | | |
| | | | | 28480 | 5080-7199 | |
| | | | | 28480 | 5080-7200 | |
| | | | | 28480 | 5081-4919 | |
| | | | | 28480 | 62048-80095 | |
| 62003A thru 62006A | Option 103 (120V ac 240V ac) | 1 | | 28480 | 2110-0067 | 5 |
| 62010A thru 62048A | Fuse, 0.3A 250V (replaces F1 if T1 wired for 240V ac) | 1 | | | | |
| | Fuse, 0.375A 250V (replaces F1 if T1 wired for 240V ac) | 1 | | 28480 | 2110-0065 | 5 |
| T1 | Power Transformer (shipped wired for 120V ac) | 1 | | | | |

| REF. DESIG. | DESCRIPTION | TQ | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|-------------------------------|-----------------------------------|----|----------------|--------------|----------------|----|
| C-SERIES (62003C thru 62048C) | | | | | | |
| | Main Power Supply Board | | | | | |
| C1 | fxd, elect. 300 μ F 40V dc | 1 | 34D307G040GJ2 | 56289 | 0180-1805 | 1 |
| C2 | fxd, mica 390pF 300V dc | 1 | | 28480 | 0140-0200 | 1 |
| C3 | fxd, mylar. 0.47 μ F 25V dc | 2 | | 28480 | 0160-0174 | 1 |
| C12 | | 1 | | | | 1 |
| 62003C thru 620028C | fxd, tantalum 4.7 μ F 35V dc | | 150D475X903582 | 56289 | 0180-0100 | |
| 620048C | fxd, tantalum 5 μ F 65V dc | | | 28480 | 0180-1836 | |
| C13 | fxd, mylar. .01 μ F 200V dc | 1 | 192P10392 | 56289 | 0160-0161 | 1 |
| C14 | fxd, mica 10pF 300V dc | 1 | RDM15C10053C | 00853 | 0160-2197 | 1 |
| C15 | fxd, mylar. 0.47 μ F 25V dc | | | 28480 | 0160-0174 | |
| C16 | fxd, mica 30pF 300V dc | 1 | ROM15E30053C | 00853 | 0160-2199 | 1 |
| C18 | fxd, mica 100pF 500V dc | 1 | RCM15E101J | 00853 | 0140-0041 | 1 |
| C19 | | 1 | | | | 1 |
| 62003C thru 62010C | fxd, mylar. .01 μ F 200V dc | | 192P10392 | 56289 | 0160-0161 | |
| 62012C thru 62018C | fxd, mylar. .0047 μ F 200V dc | | 192P47292 | 56289 | 0160-0157 | |
| 62024C thru 62048C | fxd, mylar. .001 μ F 200V dc | | | 56289 | 0160-0157 | |
| CR1,2 | Rectifier S1 200V 1A | 2 | 1N5059 | 28480 | 1901-0327 | 2 |
| CR3-6 | | 4 | | | | 4 |
| 62003C thru 62018C | Not Used | | | | | |
| 62024C thru 62048C | Rectifier S1 200V 1A | | 1N5059 | 28480 | 1901-0327 | |
| CR8,9 | Diode S1 200V 3A | 2 | 1N4999 | 28480 | 1901-0416 | 2 |
| CR11-14 | Diode S1 250mW 200V | 4 | 1N4858 | 28480 | 1901-0033 | 4 |
| CR15 | Stabistor 400mW 10V | 1 | | 28480 | 1901-0460 | 1 |
| Q1 | SS NPN S1 | 1 | 40346 | 02735 | 1854-0095 | 1 |
| Q2 | | 1 | | | | 1 |
| 62003C thru 62018C | SS PNP S1 | | | 28480 | 1853-0099 | |
| 62024C thru 62028C | SS PNP S1 | | | 28480 | 1853-0041 | |
| 62048C | SS PNP S1 | | | 28480 | 1853-0037 | |
| Q3 | | 1 | | | | 1 |
| 62003C thru 62018C | SS NPN S1 | | | 28480 | 1854-0244 | |
| 62024C thru 62048C | SS NPN S1 | | MM2258 | 04713 | 1854-0271 | |
| R1 | fxd, comp 1.5k 5% 1/2W | 1 | E8-1525 | 01121 | 0686-1525 | 1 |
| R2,3 | fxd, met. film 6.2k 1% 1/8W | 2 | Type CEA T-0 | 07716 | 0698-5087 | 1 |
| R4 | fxd, met. film 750 1% 1/8W | 1 | Type CEA T-0 | 07716 | 0757-0420 | 1 |
| R5 | fxd, ww 5.9k 1% 2/3W | 1 | | 28480 | 0811-1978 | 1 |
| R6 | | 1 | | | | 1 |
| 62003C | fxd, ww 3.6k 5% 3W | | 242E 3625 | 56289 | 0811-1810 | |
| 62004C | fxd, ww 4.7k 5% 3W | | | 28480 | 0811-1812 | |
| 62005C | fxd, ww 6.8k 5% 3W | | 242E 6825 | 56289 | 0811-0960 | |
| 62006C | fxd, ww 10k 5% 3W | | 242E 1035 | 56289 | 0811-1816 | |
| 62010C thru 62048C | Not Used | | | | | |
| R8 | | 1 | | | | 1 |
| 62003C | fxd, ww 2100 1% 1W | | | 28480 | 0811-3187 | |
| 62004C | fxd, ww 2950 1% 1W | | | 28480 | 0811-3192 | |
| 62005C | fxd, ww 3800 1% 1W | | | 28480 | 0811-3195 | |
| 62006C | fxd, ww 4660 1% 1W | | | 28480 | 0811-3193 | |
| 62010C | fxd, ww 10,750 1% 3W | | | 28480 | 0811-3194 | |

| REF. DESIG. | DESCRIPTION | TQ | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|---------------------------------------|----------------------------|----|---------------|--------------|----------------|----|
| 62012C | fxd, ww 12,900 1% 3W | | | 28480 | 0811-3186 | |
| 62015C | fxd, ww 16,100 1% 3W | | | 28480 | 0811-3196 | |
| 62018C | fxd, ww 19,350 1% 3W | | | 28480 | 0811-3190 | |
| 62024C | fxd, ww 25,800 1% 4W | | | 28480 | 0811-3188 | |
| 62028C | fxd, ww 30,050 1% 4W | | | 28480 | 0811-3191 | |
| 62048C | fxd, ww 51,550 1% 5W | | | 28480 | 0811-3197 | |
| R10 | | 1 | | | | 1 |
| 62003, 62004C | fxd, comp 430 5% 1/2W | | E8-4315 | 01121 | 0686-4315 | |
| 62005C | fxd, comp 1k 5% 1/2W | | E8-1025 | 01121 | 0686-1025 | |
| 62006C thru 62012C | fxd, comp 2k 5% 1/2W | | E8-2025 | 01121 | 0686-2025 | |
| 62015C | fxd, comp 2.4k 5% 1/2W | | E8-2425 | 01121 | 0686-2425 | |
| 62018C | fxd, comp 4.3k 5% 1/2W | | E8-4325 | 01121 | 0686-4325 | |
| 62024C | fxd, comp 4.7k 5% 1/2W | | E8-4725 | 01121 | 0686-4725 | |
| 62028C | fxd, comp 7.5k 5% 1/2W | | E8-7525 | 01121 | 0686-7525 | |
| 62048C | fxd, comp 8.2k 5% 1/2W | | E8-8225 | 01121 | 0686-8225 | |
| R11 | fxd, ww 1k 5% 3W | 1 | 242E1025 | 56289 | 0813-0001 | 1 |
| R12 | fxd, comp 7.5k 5% 1/2W | 1 | E8-7525 | 01121 | 0686-7525 | 1 |
| R13 | fxd, comp 560 5% 1/2W | 2 | E8-5615 | 01121 | 0686-5615 | 1 |
| R15 | (Current Sampling) | 1 | | | | 1 |
| 62003C thru 62015C | fxd, ww .07 5% 5W | | | 28480 | 0811-3174 | |
| 62018C | fxd, ww 0.1 5% 3W | | | 28480 | 0811-1827 | |
| 62024C, 62028C | fxd, ww 0.125 5% 3W | | Type CW28-1 | 91637 | 0811-1828 | |
| 62048C | fxd, ww 0.25 10% 3W | | Type CW28-1 | 91637 | 0811-1829 | |
| R17 | | 1 | | | | 1 |
| 62003C thru 62006C | fxd, ww 3.3 5% 2W | | Type 8WH | 07716 | 0811-1672 | |
| 62010C, 62012C | fxd, ww 3 5% 3W | | Type 242E3R05 | 56289 | 0811-1224 | |
| 62015C | fxd, ww 2.7 5% 2W | | Type 8WH | 07716 | 0811-1671 | |
| 62018C, 62028C | fxd, ww 4.3 5% 2W | | Type 8WH | 07716 | 0811-1760 | |
| 62024C | fxd, ww 4.7 5% 2W | | Type 8WH | 07716 | 0811-1674 | |
| 62048C | fxd, ww 15 5% 3W | | | 28480 | 0811-1557 | 1 |
| R18 | var. ww 100 20% | 1 | Type 110-F4 | 11236 | 2100-0281 | 1 |
| R19 | | 1 | | | | 1 |
| 62003C | fxd, met. oxide 22 5% 2W | | Type C-425 | 16299 | 0698-3609 | |
| 62004C | fxd, met. oxide 30 5% 2W | | | 28480 | 0764-0041 | |
| 62005C | fxd, met. oxide 43 5% 2W | | Type C-425 | 16299 | 0698-3614 | |
| 62006C | fxd, met. oxide 56 5% 2W | | Type C-425 | 16299 | 0764-0013 | |
| 62010C | fxd, met. oxide 100 5% 2W | | Type C-425 | 16299 | 0698-3620 | |
| 62012C | fxd, ww 135 5% 3W | | Type 242E | 56289 | 0698-3609 | |
| 62015C | fxd, met. oxide 180 5% 2W | | Type C-425 | 16299 | 0698-3626 | |
| 62018C | fxd, met. oxide 270 5% 2W | | Type C-425 | 16299 | 0698-3629 | |
| 62024C | fxd, ww 390 5% 3W | | Type 8WH | 07716 | 0811-1799 | |
| 62028C | fxd, ww 490 5% 3W | | 242E 4915 | 56289 | 0811-1801 | |
| 62048C | fxd, ww 1.4k 5% 3W | | 242E 1425 | 56289 | 0811-1804 | |
| R20 | | 1 | | | | 1 |
| 62003C thru 62006C, 62015C, 62048C | fxd, met. film 139 1% 1/8W | | Type CEA T-0 | 07716 | 0698-4099 | |
| 62010C, 62012C | fxd, met. film 110 1% 1/8W | | Type CEA T-0 | 07716 | 0757-0402 | |
| 62018C | fxd, met. film 115 1% 1/8W | | Type CEA T-0 | 07716 | 0698-4406 | |
| 62024C | fxd, met. film 150 1% 1/8W | | Type CEA T-0 | 07716 | 0757-0284 | |

| REF. DESIG. | DESCRIPTION | TQ | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|--|------------------------------|----|---------------|--------------|----------------|----|
| 62028C R21 | fxd, met. film 121 1% 1/8W | 1 | Type CEA T-0 | 07716 | 0757-4-3 | 1 |
| 62003C | fxd, met. film 61.9k 1% 1/8W | | Type CEA T-0 | 07716 | 0757-0460 | |
| 62004C, 62005C, 62010C, 62018C, 62028C | fxd, met. film 64k 1% 1/8W | | Type CEA T-0 | 07716 | 0698-6274 | |
| 62006C, 62012C, 62015C, 62024C, 62048C | fxd, met. film 68.1k 1% 1/8W | | Type CEA T-0 | 07716 | 0757-0461 | |
| R22 | fxd, comp 100 5% 1/2W | 3 | EB-1015 | 01121 | 0686-1015 | 1 |
| R23 | fxd, comp 560 5% 1/2W | | EB-5615 | 01121 | 0686-5615 | |
| R25 | fxd, comp 1.3k 5% 1/2W | 1 | E8-1325 | 01121 | 0686-1325 | 1 |
| R26 | fxd, comp 270 5% 1/2W | 1 | EB-2715 | 01121 | 0686-2715 | 1 |
| R27 | | 1 | | | | 1 |
| 62003C, 62004C | fxd, comp 10 5% 1/2W | | EB-1005 | 01121 | 0686-1005 | |
| 62024C thru 62048C | | | | | | |
| 62005C thru 62018C | fxd, comp 8.2 5% 1/2W | | EB-82G5 | 01121 | 0698-5479 | |
| R28 | fxd, comp 1k 5% 1/2W | 1 | E8-1025 | 01121 | 0686-1025 | 1 |
| R29 | | 1 | | | | 1 |
| 62003C | fxd, met. oxide 22 5% 2W | | Type C-425 | 16299 | 0698-3909 | |
| 62004C, 62005C | fxd, met. oxide 30 5% 2W | | | 28480 | 0764-0041 | |
| 62006C | fxd, met. oxide 43 5% 2W | | Type C-425 | 16299 | 0698-3614 | |
| 62010C | fxd, ww 75 5% 5W | | 243E9505 | 56289 | 0812-0097 | |
| 62012C | fxd, ww 120 5% 5W | | | 28480 | 0811-2138 | |
| 62015C | fxd, ww 150 5% 5W | | 243E1515 | 56289 | 0811-1217 | |
| 62018C | fxd, ww 200 5% 5W | | 243E2015 | 56289 | 0811-1204 | |
| 62024C | fxd, met. oxide 430 5% 2W | | Type C-425 | 16299 | 0764-0024 | |
| 62028C | fxd, ww 600 5% 5W | | 243E6015 | 56289 | 0811-1860 | |
| 62048C | fxd, ww 1.4k 5% 3W | | 242E1425 | 56289 | 0811-1804 | |
| R30 | fxd, comp 75 5% 1/2W | 1 | EB-7505 | 01121 | 0686-7505 | 1 |
| R31 | | 1 | | | | 1 |
| 62003C thru 62006C | fxd, ww 470 5% 3W | | 242E4715 | 56289 | 0811-1555 | |
| 62010C | fxd, ww 490 5% 3W | | 242E4915 | 56289 | 0811-1801 | |
| 62012C, 62015C | fxd, ww 820 5% 3W | | 242E8215 | 56289 | 0811-0010 | |
| 62018C | fxd, ww 970 5% 3W | | 242E9715 | 56289 | 0811-1802 | |
| 62024C | fxd, ww 1.5k 5% 3W | | 242E1525 | 56289 | 0811-1805 | |
| 62028C | fxd, ww 2k 5% 3W | | 242E2025 | 56289 | 0811-1806 | |
| 62048C | fxd, ww 4.7k 5% 3W | | | 28480 | 0811-1812 | |
| R32, 33 | fxd, comp 100 5% 1/2W | | E8-1015 | 01121 | 0686-1015 | |
| U1-3 | Operational Amplifier | 3 | LM301A | 07014 | 1820-0223 | 1 |
| VR1 | Diode, zener 7.5V 400mW | 1 | 1N52368 | 28480 | 1902-0064 | 1 |
| VR2 | Diode, zener 6.2V 250mW | 1 | 1N825 | 28480 | 1902-1221 | 1 |
| | Chassis Electrical | | | | | |
| C4 | fxd, mylar 0.47μF 25V dc | 1 | | 28480 | 0160-0970 | 1 |
| C9 | | 1 | | | | 1 |
| 62003C thru 62006C | fxd, elect 8600μF 20V dc | | | 28480 | 0180-2522 | |
| 62010C thru 62015C | fxd, elect 6600μF 30V dc | | | 28480 | 0180-2523 | |
| 62018C thru 62024C | fxd, elect 5800μF 50V dc | | | 28480 | 0180-2518 | |

| REF. DESIG. | DESCRIPTION | TQ | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|--------------------------------------|---|----|---------------|--------------|----------------|----|
| 62048C C11 | fxd, elect 3000 μ F 100V dc | 1 | | 28480 | 0180-2517 | 1 |
| 62003C thru 62010C | fxd, elect 3000 μ F 40V dc | | | 28480 | 0180-1899 | |
| 62012C thru 62018C | fxd, elect 1600 μ F 85V dc | | | 28480 | 0180-1986 | |
| 62024C thru 62048C F1 | fxd, elect 1000 μ F 100V dc | 1 | | 28480 | 0180-1881 | 5 |
| 62003C thru 62006C | Fuse, 1.5A 250V | | 312015 | 75915 | 2110-0043 | |
| 62010C thru 62048C | Fuse, 2A 250V | | 312002 | 75915 | 2110-0002 | |
| Q4 | Power NPN S1 | 1 | | 28480 | 1854-0563 | 1 |
| R7 | Voltage Adjust | 1 | | | | 1 |
| 62003C thru 62006C | var, ww 2700 5% 2W | | | 28480 | 2100-3255 | |
| 82010C thru 62048C T1 | var, ww 1800 5% 2W | 1 | | 28480 | 2100-3254 | 1 |
| 62003C thru 62006C | Power Transformer | | | 28480 | 5080-7196 | |
| 62010C thru 62015C | Power Transformer | | | 28480 | 5080-7197 | |
| 62018C thru 62028C | Power Transformer | | | 28480 | 5080-7198 | |
| 62048C | Power Transformer | | | 28480 | 62048-80092 | |
| TB1 | Terminal Block (Rear) 7-Terminal | 1 | | 28480 | 0360-1766 | |
| TC1 | Thermal Switch open 193 \pm 5 $^{\circ}$ F close 168 \pm 8 $^{\circ}$ F | 1 | | 28480 | 3103-0017 | 1 |
| U4 | | 1 | | | | 1 |
| 62003C thru 62024C 62028C, 62048C | Diode Assembly, Integrated Circuit Not Used | | 1N4436/T/F | 28480 | 1906-0041 | |
| | Mechanical | | | | | |
| | Cover, Front-Top | 1 | | | | |
| | 62003C | | | 28480 | 62003-60002 | |
| | 62004C | | | 28480 | 62004-60002 | |
| | 62005C | | | 28480 | 62005-60002 | |
| | 62006C | | | 28480 | 62006-60002 | |
| | 62010C | | | 28480 | 62010-60002 | |
| | 62012C | | | 28480 | 62012-60002 | |
| | 62015C | | | 28480 | 62015-60002 | |
| | 62018C | | | 28480 | 62018-60002 | |
| | 62024C | | | 28480 | 62024-60002 | |
| | 62028C | | | 28480 | 62028-60002 | |
| | 62048C | | | 28480 | 62048-60002 | |
| | Cover, Bottom-Rear | 1 | | | | |
| | 62003C thru 62006C | | | 28480 | 5060-9639 | |
| | 62010C thru 62048C | | | 28480 | 5060-9640 | |
| | Side Panel, Right | 1 | | 28480 | 5020-8092 | |
| | Side Panel, Left | 1 | | 28480 | 5020-8093 | |
| | Snap Bushing, Left Side Panel | 1 | | 28480 | 0400-0064 | |
| | Jumper, Terminal Block | 2 | | 28480 | 0360-1784 | |
| | Cover, Terminal Block | 1 | | 28480 | 4040-0948 | |

| REF. DESIG. | DESCRIPTION | TQ | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|--|---|----|----------------|-----------|-------------|----|
| | Heat Sink (Q4) | 1 | 757-T0-3 | 28480 | 5020-8404 | |
| | Insulator, Mica (Q4) | 1 | | 08530 | 0340-0181 | |
| | Shoulder Washer, Insulator (Q4) | 1 | | 28480 | | |
| | Fuseholder, F1 | 1 | 342014 | 75915 | 1400-0084 | |
| | Insulator, Fuseholder | 1 | 901-129 | 75915 | 1400-0090 | |
| | Heat Sink, Transistor (Q3) | 1 | NF-207 | 05820 | 1205-0033 | |
| | Bracket, Rear Chassis | 1 | | 28480 | 5000-9351 | |
| | Bracket, Voltage Adjust | 1 | | 28480 | 5000-9348 | |
| | Bracket, Capacitor 1 3/8" | 2 | | 28480 | 5000-9352 | |
| | Bracket, Capacitor 2" | 2 | | 28480 | 5000-9355 | |
| | Spacer 8/32 x 3/4 (T1) | 4 | | 28480 | 0380-0720 | |
| | Plug (Crowbar Adjust Hole) | 1 | | 28480 | | |
| | Packing Carton | 1 | | | 9211-1198 | |
| | Floater Pad, Packing Carton | 1 | | | 9220-1412 | |
| | Floater Pad, Packing Carton | 1 | | | 9220-1414 | |
| | Floater Pad, Packing Carton | 1 | | | 9220-1415 | |
| F1 62003C thru 62006C 62010C thru 62048C T1 62003C thru 62006C 62010C thru 62015C 62018C thru 62028C 62048C | Option 101 (220V ac) Option 102 (240V ac) | 1 | | | | 5 |
| | Fuse, 0.75A 250V | | | 28480 | 2110-0063 | 1 |
| | Fuse, 1A 250V | | | 28480 | 2110-0001 | |
| | Power Transformer (wired for 220V ac for option 101 or 240V ac for option 102) | 1 | | 28480 | 5081-4920 | |
| | | | | 28480 | 5081-4921 | |
| | | | | 28480 | 5081-4922 | |
| 62003C thru 62006C 62010C thru 62048C | Option 103 (120V ac 240V ac) Fuse, 0.75A 250V (Replaces F1 if it is wired for 240V ac) | 1 | | 28480 | 2100-0063 | 5 |
| | Fuse, 1A 250V (Replaces F1 if it is wired for 240V ac) | 1 | | 28480 | 2110-0001 | 5 |
| | Power Transformer (shipped wired for 120V ac) | 1 | | 28480 | | 1 |
| E-SERIES (62003E thru 62048E) | | | | | | |
| C1 C2 C3 C12 62003E, 62004E, 62010E 62005E, 62006E, | Main Power Supply Board | 1 | 34D307G040GJ2 | 56289 | 0180-1805 | 1 |
| | fxd, elect 300µF 40V dc | 1 | | 28480 | 0140-0200 | 1 |
| | fxd, mica 390pF 300V dc | 2 | | 28480 | 0160-0174 | 1 |
| | fxd, mylar 0.47µF 25V dc | 1 | | | | 1 |
| | fxd, tantalum 3.3µF 50V dc | | | 28480 | 0160-2141 | |
| | fxd, tantalum 1µF 35V dc | | 150D105X9035A2 | 56289 | 0180-0291 | |

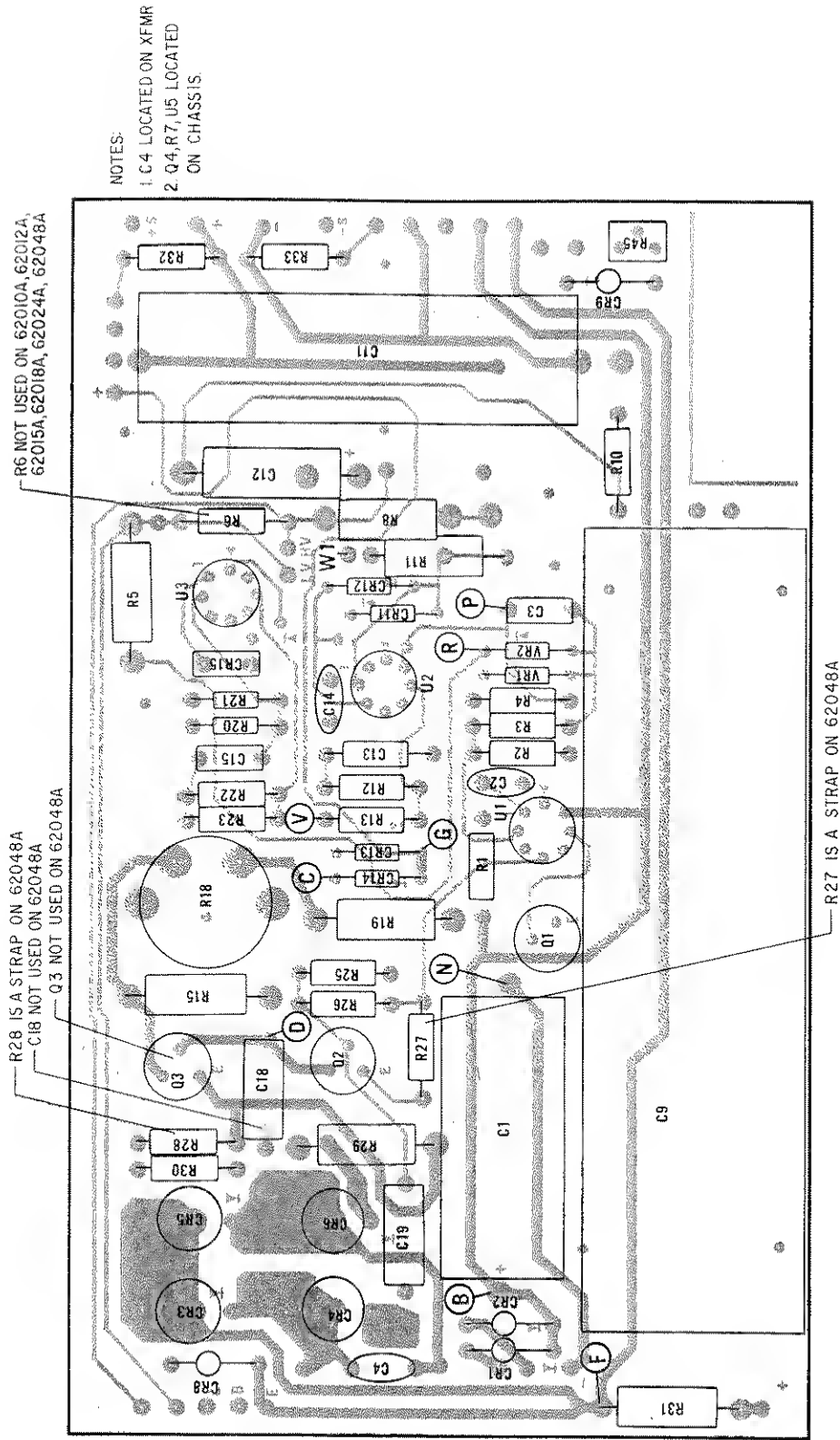
| REF. DESIG. | DESCRIPTION | TQ | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|--------------------|-----------------------------------|----|---------------|--------------|----------------|----|
| 62012E thru 62028E | | | | | | |
| 62048E | fxd, tantalum 0.47 μ F 80V dc | | 192D4749R8 | 56289 | 0160-0154 | |
| C13 | fxd, mylar .01 μ F 200V dc | 1 | 192P10392 | 56289 | 0160-0161 | 1 |
| C14 | fxd, mica 10pF 300V dc | 1 | RDM15C100J3C | 00853 | 0160-2197 | 1 |
| C15 | fxd, mylar 0.47 μ F 25V dc | | | 28480 | 0160-0174 | 1 |
| C16 | fxd, mica 30pF 300V dc | 1 | RDM15E300J3C | 00853 | 0160-2199 | 1 |
| C18 | fxd, mica 100pF 500V dc | 1 | RCM15E1015 | 00853 | 0140-0041 | 1 |
| C19 | | 1 | | | | 1 |
| 62003E thru 82006E | fxd, mylar .01 μ F 200V dc | | 192P10392 | 56289 | 0180-2141 | |
| 82010E thru 62028E | fxd, mylar .0047 μ F 200V dc | | 192D47292 | 56289 | 0160-0157 | |
| 62048E | fxd, mylar .0022 μ F 200V dc | | 192P22292 | 56289 | 0160-0154 | |
| CR1,2 | Rectifier S1 200V 1A | 2 | 1N5059 | 28480 | 1901-0327 | 2 |
| CR11-14 | Diode S1 250mV 200V | 4 | 1N4B5B | 28480 | 1901-0033 | 4 |
| CR15 | Stabistor 400mW 10V | 1 | | 28480 | 1901-0480 | 1 |
| Q1 | SS NPN S1 | 1 | 40346 | 02735 | 1854-0095 | 1 |
| Q2 | | 1 | | | | 1 |
| 62003E thru 62028E | SS PNP S1 | | | 28480 | 1853-0041 | |
| 62048E | SS PNP S1 | | | 28480 | 1853-0037 | |
| R1 | fxd, comp 1.5k 5% 1/2W | 1 | EB-1525 | 01121 | 0686-1525 | 1 |
| R2,3 | fxd, met. film 6.2k 1% 1/8W | 2 | Type CEA T-0 | 07716 | 0698-5087 | 1 |
| R4 | fxd, met. film 750 1% 1/8W | 1 | Type CEA T-0 | 07716 | 0757-0420 | 1 |
| R5 | fxd, ww 5.9k 1% 2/3W | 1 | | 28480 | 0811-1978 | 1 |
| R6 | | 1 | | | | 1 |
| 62003E | fxd, ww 3.6k 5% 3W | | 242E3625 | 56289 | 0811-1810 | |
| 62004E | fxd, ww 4.7k 5% 3W | | | 28480 | 0811-1812 | |
| 62005E | fxd, ww 6.8k 5% 3W | | 242E6825 | 56289 | 0811-0960 | |
| 62006E | fxd, ww 10k 5% 3W | | 242E1035 | 56289 | 0811-1816 | |
| 62010E thru 62048E | Not Used | | | | | |
| R8 | | 1 | | | | 1 |
| 62003E | fxd, ww 2100 1% 1W | | | 28480 | 0811-3187 | |
| 62004E | fxd, ww 2950 1% 1W | | | 28480 | 0811-3192 | |
| 62005E | fxd, ww 3800 1% 1W | | | 28480 | 0811-3195 | |
| 62006E | fxd, ww 4660 1% 1W | | | 28480 | 0811-3193 | |
| 62010E | fxd, ww 10,750 1% 3W | | | 28480 | 0811-3194 | |
| 62012E | fxd, ww 12,900 1% 3W | | | 28480 | 0811-3186 | |
| 62015E | fxd, ww 16,100 1% 3W | | | 28480 | 0811-3196 | |
| 62018E | fxd, ww 19,350 1% 3W | | | 28480 | 0811-3190 | |
| 62024E | fxd, ww 25,800 1% 4W | | | 28480 | 0811-3188 | |
| 62028E | fxd, ww 30,050 1% 4W | | | 28480 | 0811-3191 | |
| 62048E | fxd, ww 51,550 1% 5W | | | 28480 | 0811-3197 | |
| R10 | | 1 | | | | 1 |
| 62003E | fxd, comp 430 5% 1/2W | | E8-4315 | 01121 | 0686-4315 | 1 |
| 62004E thru 62010E | fxd, comp 470 5% 1/2W | | EB-4715 | 01121 | 0686-4715 | |
| 62012E thru 62028E | fxd, comp 1k 5% 1/2W | | EB-1025 | 01121 | 0686-1025 | |
| 62048E | fxd, comp 2k 5% 1/2W | | E8-2025 | 01121 | 0686-2025 | |
| R11 | fxd, ww 1k 5% 3W | 1 | 242E1025 | 58289 | 0813-0001 | 1 |
| R12 | fxd, comp 7.5k 5% 1/2W | 1 | EB-7525 | 01121 | 0686-7525 | 1 |
| R13 | fxd, comp 560 5% 1/2W | 2 | EB-5615 | 01121 | 0686-5615 | 1 |
| R15 | Current Sampling Resistor | 1 | | | | 1 |
| 62003E thru 62010E | fxd, ww .033 5% 10W | | | 28480 | 0811-3175 | |

| REF. DESIG. | DESCRIPTION | TQ | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|-------------------------------------|------------------------------|----|---------------|-----------|-------------|----|
| 62012E thru 62018E | fxd, ww .05 5% 10W | | Type CW10-1 | 91637 | 0811-1887 | |
| 62024E, 62028E | fxd, ww .07 5% 5W | | | 28480 | 0811-3174 | |
| 62048E | fxd, ww .125 10% 5W | | Type CW5-2 | 91637 | 0811-1846 | |
| R17 | | 1 | | | | 1 |
| 62003E, 62006E, 62010E | fxd, ww 6.8 5% 2W | 1 | Type 8WH | 07716 | 0811-1676 | |
| 62004E, 62018E | fxd, ww 2.7 5% 2W | | Type 8WH | 07716 | 0811-1671 | |
| 62005E, 62012E, 62015E | fxd, ww 3.9 5% 2W | | Type 8WH | 07716 | 0811-1673 | |
| 62024E | fxd, ww 3 5% 3W | | 242E3R05 | 56289 | 0811-1224 | |
| 62028E | fxd, ww 7.5 5% 2W | | Type BWH | 07716 | 0811-2553 | |
| 62048E | fxd, ww 5.6 5% 2W | | | 28480 | 0811-1675 | |
| R18 | var, ww 100 20% | 1 | Type 110-F4 | 11236 | 2100-0281 | 1 |
| R19 | | 1 | | | | 1 |
| 62003E | fxd, ww 10 5% 3W | | 242E1005 | 56289 | 0811-1718 | |
| 62004E, 62005E | fxd, ww 22 5% 2W | | Type C-425 | 16299 | 0698-3609 | |
| 62006E | fxd, ww 25 5% 5W | | | 28480 | 0811-1853 | |
| 62010E, 62012E | fxd, ww 50 5% 5W | | 242E5005 | 56289 | 0811-1854 | |
| 62015E | fxd, ww 75 5% 5W | | 243E7505 | 56289 | 0812-0097 | |
| 62018E | fxd, ww 135 5% 5W | | 243E | 56289 | 0812-0098 | |
| 62024E | fxd, ww 200 5% 5W | | 243E2015 | 56289 | 0811-1224 | |
| 62028E | fxd, ww 300 5% 5W | | 243E3015 | 56289 | 0811-1215 | |
| 62048E | fxd, ww 750 5% 5W | | 243E7515 | 56289 | 0811-1861 | |
| R20 | | 1 | | | | 1 |
| 62003E | fxd, met. film 150 1% 1/8W | | Type CEA T-0 | 07716 | 0757-0284 | |
| 62004E, 62005E, 62024E | fxd, met. film 139 1% 1/8W | | Type CEA T-0 | 07716 | 0698-4099 | |
| 62006E | fxd, met. film 130 1% 1/8W | | Type CEA T-0 | 07716 | 0757-0404 | |
| 62010E, 62028E | fxd, met. film 115 1% 1/8W | | Type CEA T-0 | 07716 | 0698-4406 | |
| 62012E | fxd, met. film 107 1% 1/8W | | Type CEA T-0 | 07716 | 0698-4405 | |
| 62015E | fxd, met. film 182 1% 1/8W | | Type CEA T-0 | 07716 | 0757-0406 | |
| 62018E | fxd, met. film 162 1% 1/8W | | Type CEA T-0 | 07716 | 0757-0405 | |
| 62048E | fxd, met. film 110 1% 1/8W | | Type CEA T-0 | 07716 | 0757-0402 | |
| R21 | fxd, met. film 68.1k 1% 1/8W | 1 | Type CEA T-0 | 07716 | 0757-0461 | 1 |
| R22 | fxd, comp 100 5% 1/2W | 3 | E8-1015 | 01121 | 0686-1015 | 1 |
| R23 | fxd, comp 560 5% 1/2W | | EB-5615 | 01121 | 0686-5615 | |
| R25 | fxd, comp 1.3k 5% 1/2W | 1 | E8-1325 | 01121 | 0686-1325 | 1 |
| R26 | fxd, comp 270 5% 1/2W | 1 | E8-2715 | 01121 | 0686-2715 | 1 |
| R27 | | 1 | | | | 1 |
| 62003E, 62004E, 62006E, thru 62012E | fxd, comp 6.8 5% 1/2W | | | 28480 | 0686-5525 | |
| 62005E | fxd, comp 5.1 5% 1/2W | | | 28480 | 0686-0515 | |
| 62015E thru 62028E | fxd, comp 10 5% 1/2W | | E8-1005 | 01121 | 0686-1005 | |
| 62048E | fxd, comp 12 5% 1/2W | | EB-1205 | 01121 | 0686-1205 | |
| R28 | fxd, comp 75 5% 1/2W | 1 | EB-7505 | 01121 | 0686-7525 | 1 |
| R29 | | 1 | | | | 1 |
| 62003E | fxd, ww 5.1 5% 2W | 1 | Type 8WH | 07716 | 0811-1761 | 1 |
| 62004E | fxd, ww 10 5% 3W | | 242E1005 | 56289 | 0811-1718 | |
| 62005E | fxd, ww 15 5% 3W | | | 28480 | 0811-1557 | |

| REF. DESIG. | DESCRIPTION | TQ | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|--------------------|----------------------------------|----|---------------|--------------|----------------|----|
| 62006E | fxd, ww 20 5% 5W | | 28480 | 28480 | 0813-0040 | |
| 62010E | fxd, ww 40 5% 5W | | | 28480 | 0812-0083 | |
| 62012E | fxd, ww 50 5% 5W | | 243E5005 | 56289 | 0811-1854 | |
| 62015E | fxd, ww 75 5% 5W | | 243E7505 | 56289 | 0812-0097 | |
| 62018E | fxd, ww 135 5% 5W | | 243E1315 | 56289 | 0812-0098 | |
| 62024E | fxd, ww 200 5% 5W | | 243E2015 | 56289 | 0811-1204 | |
| 62028E | fxd, ww 300 5% 5W | | 243E3015 | 56289 | 0811-1215 | |
| 62048E | fxd, ww 680 5% 5W | | 243E6815 | 56289 | 0811-2099 | |
| R30 | fxd, comp 33 5% 1/2W | 1 | EB-3305 | 01121 | 0686-3305 | 1 |
| R31 | | 1 | | | | 1 |
| 62003E thru 62006E | fxd, ww 200 5% 5W | | 243E2015 | 56289 | 0811-1204 | |
| 62010E, 82012E | fxd, ww 400 5% 5W | | 243E4015 | 56289 | 0811-1857 | |
| 62015E, 62018E | fxd, ww 600 5% 5W | | 243E6015 | 56289 | 0811-1860 | |
| 62024E, 62028E | fxd, ww 1k 5% 5W | | 243E1025 | 56289 | 0811-0099 | |
| 62048E | fxd, ww 3k 5% 5W | | 243E3025 | 56289 | 0812-0050 | |
| R32, 33 | fxd, comp 100 5% 1/2W | | E8-1015 | 01121 | 0686-1015 | |
| R34, 36 | | 2 | | | | 1 |
| 62003E thru 62005E | fxd, ww 0.18 5% 10W | | | 28480 | | |
| 62006E thru 62012E | fxd, ww 0.33 5% 5W | | | 28480 | 0811-3176 | |
| 62015E thru 62024E | fxd, ww 0.5 5% 5W | | Type CW5-2 | 91637 | 0811-1848 | |
| 62028E | fxd, ww 0.6 5% 10W | | Type CW10-1 | 91637 | 0811-1890 | |
| 62048E | fxd, ww 1 5% 5W | | 243E1R05 | 56289 | 0811-1340 | |
| U1-3 | Operational Amplifier | 3 | LM301A | 07014 | 1820-0223 | 1 |
| VR1 | Diode, zener 7.5V 400mW | 1 | 1N52368 | 28480 | 1902-0064 | 1 |
| VR2 | Diode, zener 6.2V 250mW | 1 | 1N825 | 28480 | 1902-1221 | 1 |
| | Chassis Electrical | | | | | |
| C4 | fxd, mylar 0.47 μ F 80V dc | 1 | 192PA749R8 | 56289 | 0160-0970 | 1 |
| C5 | | 1 | | | | 1 |
| 62003E thru 62028E | fxd, mylar 0.47 μ F 80V dc | | 192PA749R8 | 56289 | 0160-0970 | |
| 62048E | Not Used | | | | | |
| C9 | | 1 | | | | 1 |
| 62003E thru 62006E | fxd, elect 20,000 μ F 20V dc | | | 28480 | 0180-2524 | 1 |
| 62010E thru 62015E | fxd, elect 15,000 μ F 20V dc | | | 28480 | 0180-2525 | |
| 62018E thru 62028E | fxd, elect 10,000 μ F 50V dc | | | 28480 | 0180-2526 | |
| 62048E | fxd, elect 5,900 μ F 85V dc | | | 28480 | 0180-2527 | |
| C11 | | 1 | | | | 1 |
| 62003E thru 62012E | fxd, elect 8600 μ F 25V dc | | | 28480 | 0180-1882 | |
| 62015E thru 62048E | fxd, elect 3000 μ F 40V dc | | | 28480 | 0180-1899 | |
| F1 | | 1 | | | | 5 |
| 62003E thru 62006E | Fuse 3A 250V | | 312003 | 75915 | 2110-0003 | |
| 62012E thru 62048E | Fuse 4A 250V | | 312004 | 75915 | 2110-0055 | |
| Q3,4,5 | Power NPN S1 | 3 | | 28480 | 1854-0563 | 3 |
| R7 | Voltage Adjust | 1 | | | | 1 |
| 62003E thru 62006E | var, ww 2700 5% 2W | | | 28480 | 2100-3255 | |
| 62010E thru 62048E | var, ww 1800 5% 2W | | | 28480 | 2100-3254 | |
| T1 | | 1 | | | | 1 |
| 62003E | Power Transformer | | | 28480 | 62003-80093 | |
| 62004E | Power Transformer | | | 28480 | 62004-80093 | |

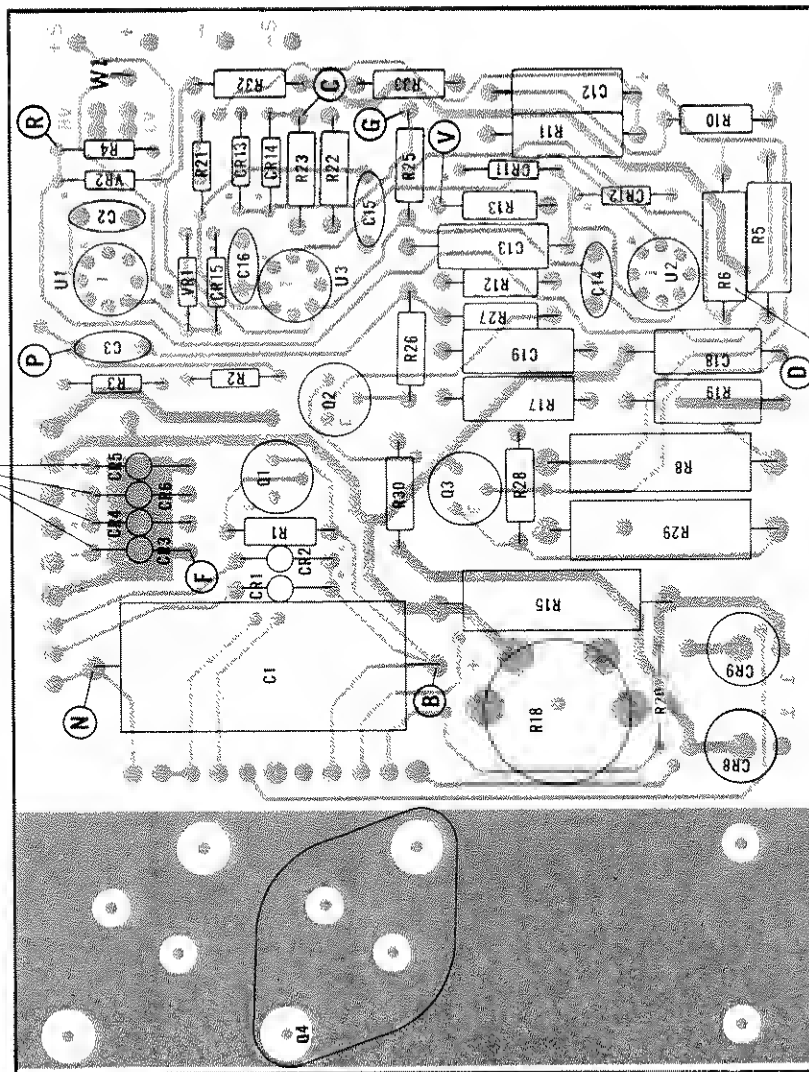
| REF. DESIG. | DESCRIPTION | TO | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|---------------------------|---|----|---------------|--------------|----------------|----|
| 62005E | Power Transformer | | | 28480 | 62005-80093 | |
| 62006E | Power Transformer | | | 28480 | 62006-80093 | |
| 62010E | Power Transformer | | | 28486 | 62010-80093 | |
| 62012E | Power Transformer | | | 28480 | 62012-80093 | |
| 62015E | Power Transformer | | | 28480 | 62015-80093 | |
| 62018E | Power Transformer | | | 28480 | 62018-80093 | |
| 62024E | Power Transformer | | | 28480 | 62024-80093 | |
| 62028E | Power Transformer | | | 28480 | 62028-80093 | |
| 62048E | Power Transformer | | | 28480 | 62048-80093 | |
| T61 | Terminal Block (Rear) 7-Terminal | 1 | | 28480 | 3103-0017 | 1 |
| TC1 | Thermal Switch open 248°F ±6°F close 223°F ±8°F | 1 | | 28460 | 3103-0019 | 1 |
| U4 62003E thru 620028E | Diode Assembly Integrated Circuit | 1 | | 28480 | 1906-0039 | 1 |
| 62048E | Diode Assembly Integrated Circuit | | | 28480 | 1906-0041 | |
| U5 | Full Wave Doubler 100prv 15A | 1 | | 28480 | 1906-0040 | 1 |
| | Mechanical | | | | | |
| | Cover, Top-Rear | 1 | | | | |
| | 62003E | | | 28480 | 62003-60003 | |
| | 62004E | | | 28480 | 62004-60003 | |
| | 62005E | | | 28480 | 62005-60003 | |
| | 62006E | | | 28480 | 62006-60003 | |
| | 62010E | | | 28480 | 62010-60003 | |
| | 62012E | | | 28480 | 62012-60003 | |
| | 62015E | | | 28480 | 62015-60003 | |
| | 62018E | | | 28480 | 62018-60003 | |
| | 62024E | | | 28480 | 62024-60003 | |
| | 62026E | | | 28480 | 62028-60003 | |
| | 62048E | | | 28480 | 62048-60003 | |
| | Cover, Bottom-Rear | 1 | | | | |
| | 62003E thru 62006E | | | 28480 | 5060-9641 | |
| | 62010E thru 62048E | | | 28480 | 5060-9642 | |
| | Bracket, 2" (C11) | 2 | | | | |
| | 62003E thru 62028E | | | 28480 | 5000-9355 | |
| | 62048E Not Used | | | | | |
| | Bracket 1 3/8" (C11) | | | | | |
| | 62003E thru 62028E Not Used | | | | | |
| | 62048E | 1 | | 28480 | 5000-9353 | |
| | Heat Sink Transistor (Q2) | 1 | | | | |
| | 62006E thru 62018E Not Used | | | | | |
| | 62024E thru 62048 | | | 28480 | 1250-0030 | |
| | Side Panel, Right | 1 | | 28480 | 5020-8092 | |
| | Side Panel, Left | 1 | | 28480 | 5020-8094 | |
| | Snap Bushing, Left Side Panel | 1 | | 28480 | 0400-0064 | |

| REF. DESIG. | DESCRIPTION | TQ | MFR. PART NO. | MFR. CODE | HP PART NO. | RS |
|--|---|----|-------------------|--------------|----------------|----|
| | Terminal Block, Jumper | 2 | 757-T0-3 | 28480 | 0360-1784 | |
| | Terminal Block, Cover | 1 | | 28480 | 4040-0948 | |
| | Heat Sink (Q3-Q5) | 1 | | 28480 | 5020-8404 | |
| | Insulator, Mica (Q3-Q5) | 3 | | 08530 | 0340-0181 | |
| | Shoulder washer, Insulator (Q3-Q5) | 3 | | 28480 | | |
| | Thermal Compound (Heat Sink) | | 342014 901-129 | 28480 | 6040-0625 | |
| | Fuseholder, F1 | 1 | | 75915 | 1400-0084 | |
| | Insulator, Fuseholder | 1 | | 75915 | 1400-0090 | |
| | Bracket, Rear Chassis | 1 | | 28480 | 5000-9351 | |
| | Bracket, Voltage Adjust | 1 | | 28480 | 500-9348 | |
| | Bracket, 2" (C9) | 2 | | 28480 | 5000-9355 | |
| | Spacer, 8/32" x 3/4" (T1) | 4 | | 28480 | 0380-0720 | |
| | Plug (Crowbar Adjust Hole) | 1 | | 28480 | | |
| | Packing Carton | 1 | | | 9211-1198 | |
| | Floater Pad, Packing Carton | 1 | | | 9220-1412 | |
| | Floater Pad, Packing Carton | 1 | | | 9220-1414 | |
| | Floater Pad, Packing Carton | 1 | | | 9220-1415 | |
| F1 62003E thru 62006E 62010E thru 62048E T1 | Option 101 (220V ac) Option 102 (240V ac) | 1 | | | | 5 |
| | Fuse, 1.5A 250V | | | 28480 | 2100-0043 | 1 |
| | Fuse, 20A 250V | | | 28480 | 2100-0262 | |
| | Power Transformer (wired for 220V ac for option 101 or 240V ac for option 102) | 1 | | | | |
| | | | | 28480 | 62003-80097 | |
| | | | | 28480 | 62004-80097 | |
| | | | | 28480 | 62005-80097 | |
| | | | | 28480 | 62006-80097 | |
| | | | | 28480 | 62010-80097 | |
| | | | | 28480 | 62012-80097 | |
| | | | | 28480 | 62015-80097 | |
| | | | | 28480 | 62018-80097 | |
| | | | | 28480 | 62024-80097 | |
| | | | | 28480 | 62028-80097 | |
| | | | | 28480 | 62048-80097 | |
| 62003E thru 62006E 62010E T1 | Option 103 (120V ac 240V ac) Fuse 1.5A 250V (replaces F1 of T1 wired for 240Vac) | 1 | | 28480 | 2100-0043 | |
| | Fuse, 2.0A 250V (replaces F1 of T1 wired for 240Vac) | | | 28480 | 2100-0262 | |
| | Power Transformer (wired for 120V ac) | 1 | | 28480 | | |



A-Series Supplies, Component Location

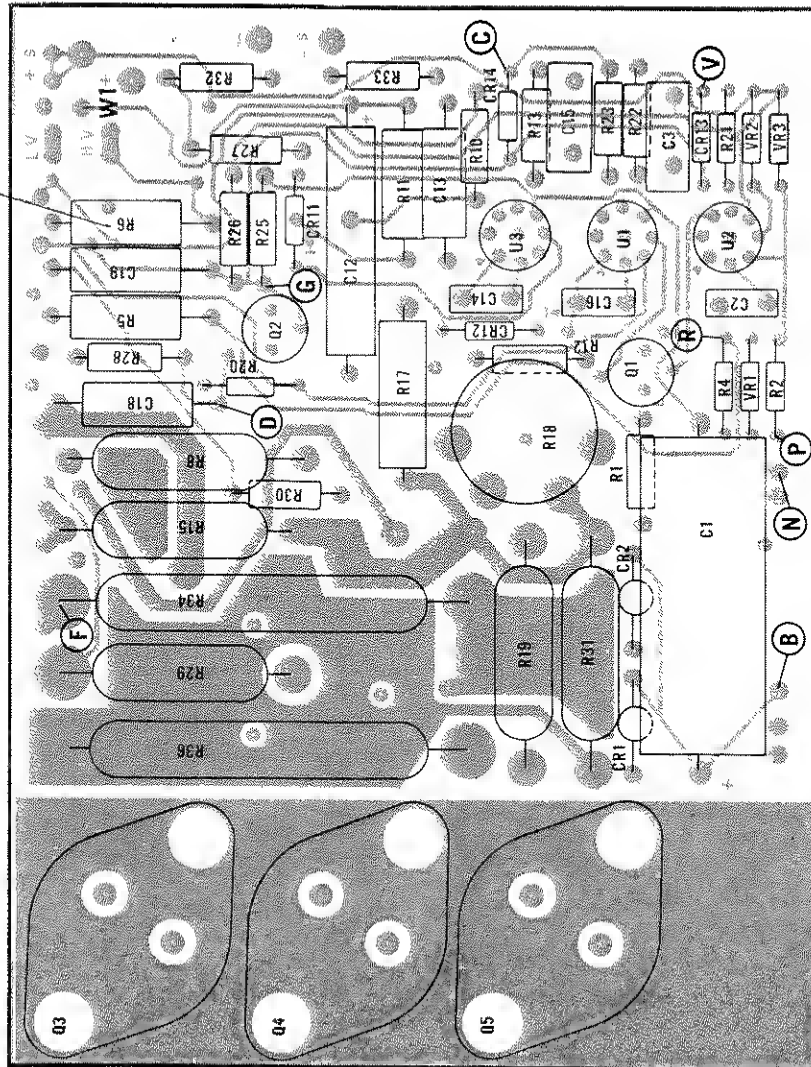
CR3, CR4, CR5, CR6 NOT USED ON 62003C,
62004C, 62005C, 62006C, 62010C, 62012C,
62015C. (USE U4 LOCATED ON CHASSIS)



- NOTES:
1. C4 LOCATED ON XFMR
 2. C9, C11, R7 LOCATED ON CHASSIS

R6 NOT USED ON 62010C, 62012C, 62015C,
62018C, 62024C, 62028C, 62048C

NOT USED ON 62010E, 62012E, 62015E
62018E, 62024E, 62028E, 62048E

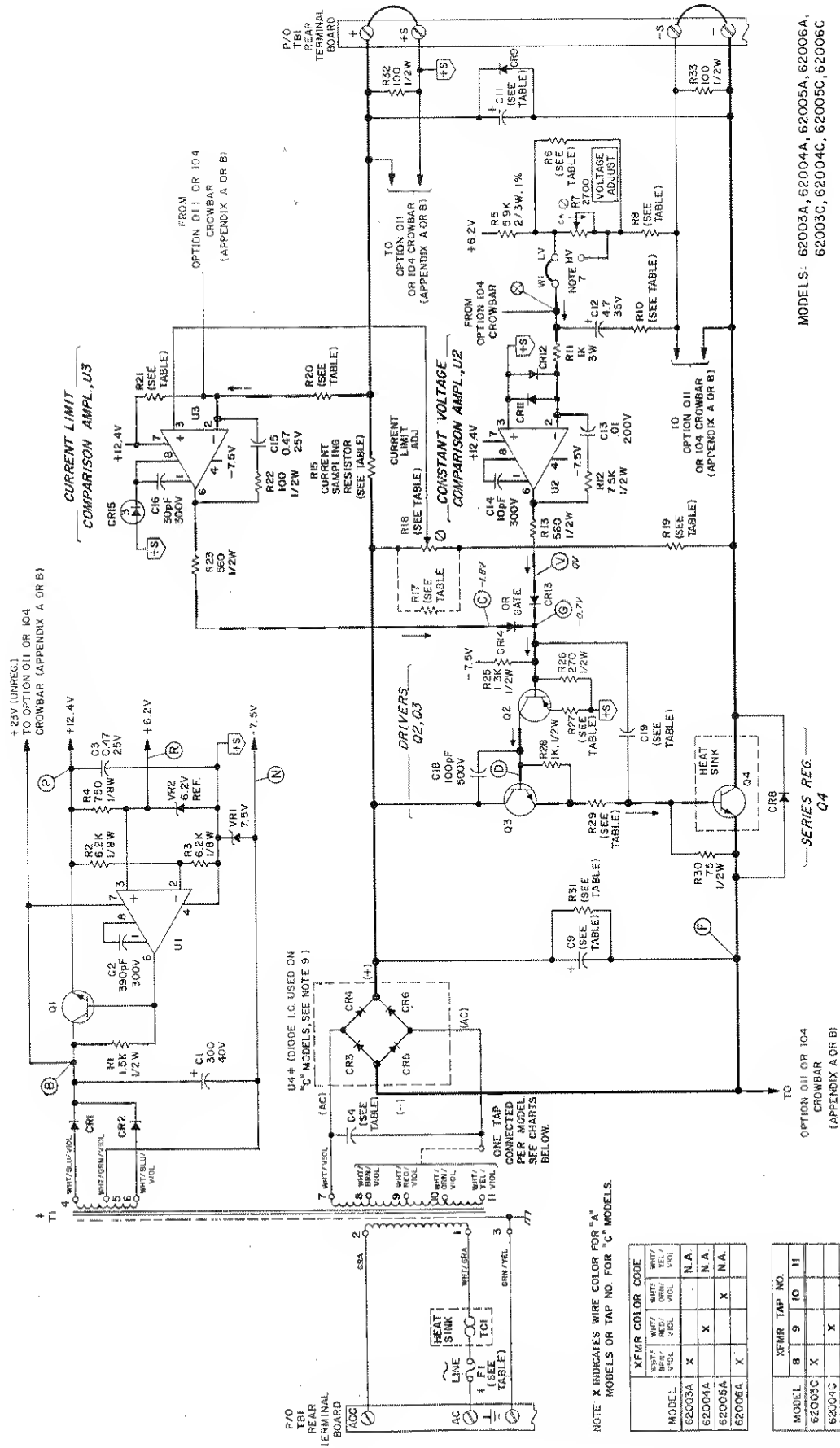


NOTES:

1. C4, C5 LOCATED ON XFMR.
2. C9, C11 LOCATED ON CHASSIS.
3. U4, U5 LOCATED ON CHASSIS.
4. R7 LOCATED ON CHASSIS.

E-Series Supplies, Component Location

REFERENCE SUPPLY



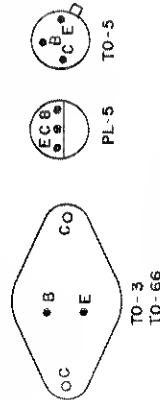
MODELS: 62003A, 62004A, 62005A, 62006A, 62003C, 62004C, 62005C, 62006C

| MODEL | OUTPUT VOLTAGE (VOC) | OUTPUT CURRENT (ADC @ 50° C) | TEST POINT (F) VOLTAGE | SCHEMATIC COMPONENTS | | | | | | | | | | | | | | | | | | R3i | FI |
|--------|----------------------|------------------------------|------------------------|----------------------|----------|--------------|---------------|------------|----------|------------|------------|------------|---------------|----------|-----|-------|----------|------------|----------|--------|--------|-----------|----|
| | | | | CR3-CR6 | C4 | C9 | C11 | C19 | U4 | R6 | R8 | R10 | R15 | R17 | R18 | R19 | R20 | R21 | R27 | R29 | | | |
| 62003A | 3 ± 0.5V | 2 | -12V | | | | | | | | 3.6K 3W 1W | 2100 3W 1W | | | | | | | | | 30 2W | | |
| 62004A | 4 ± 0.5V | 2 | -13V | | | | | | | | 4.7K 3W 1W | 2950 3W 1W | | | | | | | | | | | |
| 62005A | 5 ± 0.5V | 2 | -15V | | .05 400V | 6000 25V 30V | 1400 30V 200V | .0047 200V | NOT USED | 6.8K 3W 1W | 3800 3W 1W | 1K 1/2W | 0.125 3W USED | NOT USED | 5 | 30 2W | 139 1/8W | 681K 1/8W | 12 1/2W | 56 2W | 15K 1W | 0.5A 250V | |
| 62006A | 6 ± 0.6V | 1.75 | -16V | | | | | | | 10K 3W 1W | 4660 3W 1W | | 0.15 3W | | | | 150 1/8W | | | 100 2W | | | |
| 62003C | 3 ± 0.5V | 4.25 | -12V | | | | | | | 3.6K 3W 1W | 2100 3W 1W | 430 1/2W | | | | 22 2W | | 61.9K 1/8W | 10 1/2W | 22 2W | | | |
| 62004C | 4 ± 0.5V | 4 | -13V | | | | | | | 4.7K 3W 1W | 2950 3W 1W | 1K 1/2W | .07 5W | 3.3 2W | 100 | 30 2W | 139 1/8W | 64K 1/8W | | 30 2W | 470 3W | 1.5A 250V | |
| 62005C | 5 ± 0.5V | 4 | -15V | | | | | | USED | 6.8K 3W 1W | 3800 3W 1W | 2K 1/2W | | | | 56 2W | | 681K 1/8W | 8.2 1/2W | 43 2W | | | |
| 62006C | 6 ± 0.5V | 3.75 | -16V | | | | | | | 10K 3W 1W | 4660 3W 1W | 2K 1/2W | | | | 56 2W | | 681K 1/8W | | 43 2W | | | |

NOTES:

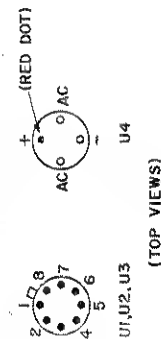
- ALL COMPONENTS ARE LOCATED ON P.C. BOARD UNLESS OTHERWISE INDICATED.
- # DENOTES CHASSIS MOUNTED COMPONENTS.
- DENOTES CONSTANT VOLTAGE FEEDBACK PATH.
- DENOTES CURRENT FEEDBACK PATH.
- ALL RESISTORS ARE IN OHMS.
ALL 1/2W RESISTORS, ±5%, UNLESS OTHERWISE INDICATED.
ALL 1/8W RESISTORS, ±1%, UNLESS OTHERWISE INDICATED.
- ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE INDICATED.
- JUMPER W1 IS CONNECTED TO LV PAD FOR ALL LOW VOLTAGE (BELOW 10V) SUPPLIES AND TO HV FOR ALL HIGHER VOLTAGE (10V AND ABOVE) SUPPLIES. SEPARATE SCHEMATICS ARE SHOWN FOR EACH TYPE.
- TEST POINT VOLTAGES MEASURED UNDER THE FOLLOWING CONDITIONS.
A. HP MODEL 427A OR EQUIVALENT
B. 115VAC INPUT
C. ALL VOLTAGES REFERENCED TO +S.
D. READINGS ARE TYPICAL ±10%
E. ALL READINGS TAKEN IN CONSTANT VOLTAGE OPERATION
- RECTIFIER CONSISTS OF DISCRETE DIODES (CR3-CR6) IN MODELS 62003A THRU 62006A. RECTIFIER IS I.C. PACKAGE (U4) IN MODELS 62003C THRU 62006C SEE NOTE 11 FOR PIN LOCATIONS OF U4.

10. PIN LOCATIONS FOR TRANSISTORS ARE SHOWN BELOW:



(TOP VIEWS)



11. PIN LOCATIONS FOR INTEGRATED CIRCUITS U1 - U4 ARE SHOWN BELOW:



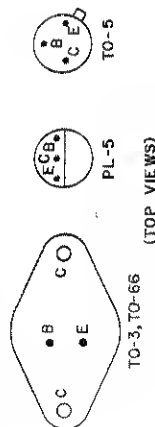
(TOP VIEWS)

| MODEL | OUTPUT VOLTAGE (VDC) | OUTPUT (ADC @ 50°C) | TEST POINT (F) VOLTAGE | SCHEMATIC COMPONENTS | | | | | | | | | | | |
|--------|----------------------|---------------------|------------------------|----------------------|------------|------------|-------------|-----------|----------|-------------|-------------|-----------|-------------|--|--|
| | | | | C12 | R6 | R8 | R10 | R17 | R19 | R20 | R27 | R29 | R34 R35 | | |
| 62003E | 3 ± 0.5 | 8.5 | -12V | 3.3 50V | 3.6K 3W | 2100 1W | 430 1/2W | 68 2W | 10 2W | 150 1/8W | 6.8 1/2W | 5.1 2W | | | |
| 62004E | 4 ± 0.5 | 8.0 | -13V | | 4.7K 3W | 2950 1W | | 2.7 2W | 22 3W | 139 1/8W | 5.1 1/2W | 15 3W | 0.18 10W | | |
| 62005E | 5 ± 0.5 | 8.0 | -15V | 1 | 6.8K 3W | 3800 1W | 470 1/2W | 39 2W | | | | | | | |
| 62006E | 6 ± 0.5 | 7.5 | -16V | 35V | 10K 3W | 4660 1W | | 6.8 2W | 25 5W | 130 1/8W | 6.8 1/2W | 20 5W | 0.33 10W | | |

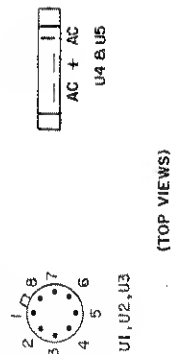
NOTES:

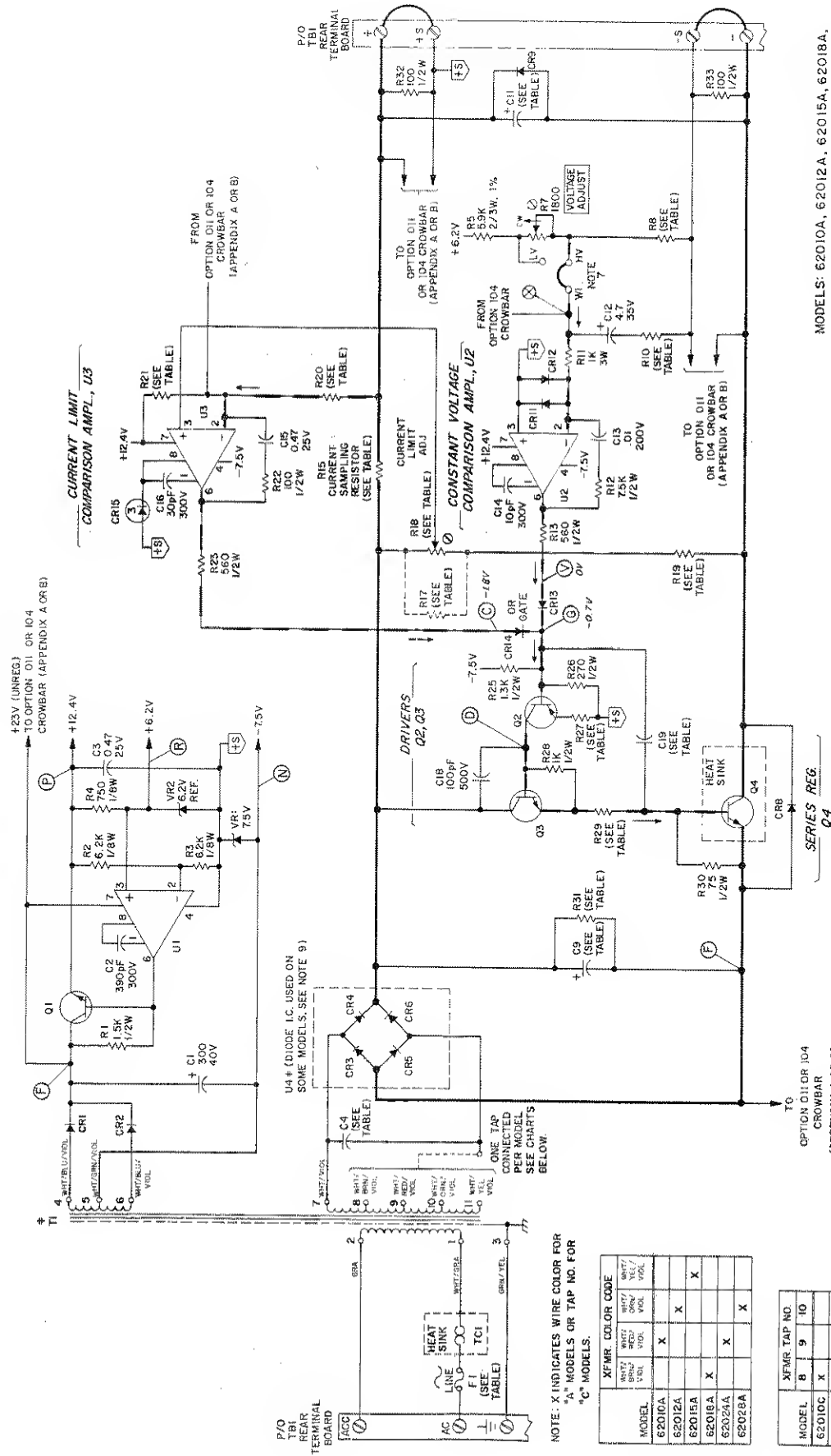
- ALL COMPONENTS ARE LOCATED ON PC BOARD UNLESS OTHERWISE INDICATED.
- # DENOTES CHASSIS MOUNTED COMPONENTS
-  DENOTES CONSTANT VOLTAGE FEEDBACK PATH.
-  DENOTES CURRENT FEEDBACK PATH.
- ALL RESISTORS IN OHMS.
ALL 1/2W RESISTORS ±5%, UNLESS OTHERWISE INDICATED.
ALL 1/8W RESISTORS ±1%, UNLESS OTHERWISE INDICATED.
- ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE INDICATED.
- JUMPER W1 IS CONNECTED TO LV PAD FOR ALL LOW VOLTAGE (BELOW 10V) SUPPLIES AND TO HV FOR ALL HIGHER VOLTAGE (10V AND ABOVE) SUPPLIES. SEPARATE SCHEMATICS ARE SHOWN FOR EACH TYPE.
- TEST POINT VOLTAGES MEASURED UNDER THE FOLLOWING CONDITIONS:
A. HP MODEL 427A OR EQUIVALENT.
B. 115VAC INPUT.
C. ALL VOLTAGES REFERENCED TO +S.
D. READINGS ARE TYPICAL ±10%.
E. ALL READINGS TAKEN IN CONSTANT VOLTAGE OPERATION.

9. PIN LOCATIONS FOR TRANSISTORS ARE SHOWN BELOW:



10. PIN LOCATIONS FOR INTEGRATED CIRCUITS U1 THRU U5 ARE SHOWN BELOW:





NOTE: X INDICATES WIRE COLOR FOR
 "A" MODELS OR TAP NO. FOR
 "C" MODELS.

| MODEL | XFMR COLOR CODE | | | | |
|--------|----------------------|-----------------------|-----------------------|------------------------|---|
| | WHT2 SNG V IOL | WHT2 #2CD V IOL | WHT1 ORNG V IOL | WHT1 YEL / V IOL | |
| 62010A | | X | | | |
| 62012A | | | X | | |
| 62015A | | | | X | |
| 62018A | X | | | | |
| 62024A | | X | | | |
| 62028A | | | | | Y |

| MODEL | XFM. TAP NO. | | |
|--------|--------------|---|----|
| | 8 | 9 | 10 |
| 62010C | X | | |
| 62012C | | X | |
| 62015C | | | X |
| 62018C | X | | |
| 62024C | | X | |
| 62028C | | | X |
| 62043C | X | | |

MODELS: 62010A, 62012A, 62015A, 62018A,
62024A, 62028A, 62010C, 62012C,
62015C, 62018C, 62024C, 62028C,
62048C

| SCHEMATIC COMPONENTS | | | | | | | | | | | | | | | | | | | | | | |
|----------------------|----------------------|----------------------|----------|----------|-----------|-----------|---------|------------|----------|----------|-----------|----------|------------|-----|---------|----------|------------|----------|---------|---------|------------|---------|
| MODEL | OUTPUT POINT | | CR3-CR6 | C4 | C9 | C11 | C12 | C19 | U4 | R8 | R10 | R15 | R17 | R18 | R19 | R20 | R21 | R27 | R29 | R31 | F1 | |
| | OUTPUT VOLTAGE (VDC) | CURRENT (ADC @ 50°C) | | | | | | | | | | | | | | | | | | | | VOLTAGE |
| 62010A | 10±0.50 | 1.50 | | | 6000 25V | | | .0033 200V | | 10750 3W | | | | | | 150 1/8W | | | 200 2W | 1.5K 1W | | |
| 62012A | 10±0.50 | 1.50 | | | | | | | | 12900 3W | 3.9K 1/2W | 0.15 3W | | | 270 2W | | | | 270 2W | | | |
| 62015A | 15±0.75 | 1.25 | USED | .05 400V | 3000 50V | 1400 30V | | | NOT USED | 16100 3W | 4.3K 1/2W | 0.25 3W | NOT ASSIGN | 10 | 270 2W | 107 1/8W | 68.1K 1/8W | 12 1/2W | 390 2W | 3K 1W | 0.75A 250V | |
| 62018A | 18±0.90 | 1.00 | | | | | | .0047 200V | | 25600 4W | 5.6K 1/2W | 0.33 2W | | | | 139 1/8W | | | 680 2W | 5.1K 1W | | |
| 62024A | 24±1.20 | 0.75 | | | | 490 65V | | | | 30050 4W | 7.5K 1/2W | | | | 560 2W | | | | 820 2W | | | |
| 62028A | 28±1.40 | 0.70 | | | | 3000 40V | 4.7 35V | .01 200V | | 10750 3W | 2K 1/2W | | 3 3W | | 100 2W | 110 1/8W | 64K 1/8W | | 75 5W | 490 3W | | |
| 62010C | 10±0.50 | 3.25 | | | 6600 30V | | | | USED | 12900 3W | 1/2W | .07 5W | | | 135 3W | | | | 120 5W | | | |
| 62012C | 12±0.60 | 3.00 | NOT USED | | | | | .0047 200V | | 16100 3W | 2.4K 1/2W | | 2.7 2W | | 180 2W | 139 1/8W | 68.1K 1/8W | 8.2 1/2W | 150 5W | 820 3W | | |
| 62015C | 15±0.75 | 2.50 | | | | 1600 85V | | | | 19350 3W | 4.3K 1/2W | 0.1 3W | 4.3 2W | 100 | 270 2W | 115 1/8W | 64K 1/8W | | 200 5W | 970 3W | 2A 250V | |
| 62018C | 18±0.90 | 2.25 | | | | | | | | 25600 4W | 4.7K 1/2W | 0.125 3W | 4.7 2W | | 390 3W | 150 1/8W | 68.1K 1/8W | | 430 2W | 1.5K 3W | | |
| 62024C | 24±1.20 | 1.75 | USED | | 5800 50V | | | .001 200V | NOT USED | 30050 4W | 7.5K 1/2W | 4.3 3W | 4.3 2W | | 490 3W | 121 1/8W | 64K 1/8W | 10 1/2W | 600 5W | 2K 3W | | |
| 62028C | 28±1.40 | 1.50 | | | 3000 100V | 1000 100V | 5 65V | | | 51550 5W | 8.2K 1/2W | 0.25 3W | 15 3W | | 1.4K 3W | 139 1/8W | 68.1K 1/8W | | 1.4K 3W | 4.7K 3W | | |
| 62048C | 48±2.40 | 1.00 | | | | | | | | | | | | | | | | | | | | |

NOTES:
 1. ALL COMPONENTS ARE LOCATED ON P.C. BOARD UNLESS OTHERWISE INDICATED.
 2. * DENOTES CHASSIS MOUNTED COMPONENTS.

3. ——— DENOTES CONSTANT VOLTAGE FEEDBACK PATH
 4. ——— DENOTES CURRENT FEEDBACK PATH.

5. ALL RESISTORS IN OHMS.
 ALL 1/2W RESISTORS ±5%, UNLESS OTHERWISE INDICATED.
 ALL 1/8W RESISTORS ±1%, UNLESS OTHERWISE INDICATED.

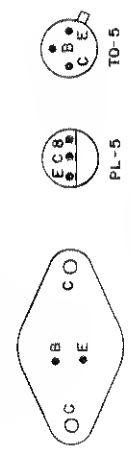
6. ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE INDICATED.

7. JUMPER W1 IS CONNECTED TO LV PAD FOR ALL LOW VOLTAGE (BELOW 10V) SUPPLIES AND TO HIGHER VOLTAGE (10V AND ABOVE) SUPPLIES. SEPARATE SCHEMATICS ARE SHOWN FOR EACH TYPE.

8. TEST POINT VOLTAGES MEASURED UNDER THE FOLLOWING CONDITIONS
 A. HP MODEL 427A OR EQUIVALENT
 B. 115VAC INPUT
 C. ALL VOLTAGES REFERENCED TO +S.

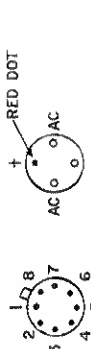
D. READINGS ARE TYPICAL ±
 E. ALL READINGS TAKEN IN CONSTANT VOLTAGE OPERATION

9. MODELS 62010C THRU 62018C USE DIODE I.C. PACKAGE, REMAINING MODELS USE DISCRETE DIODES, CR3 THRU CR6

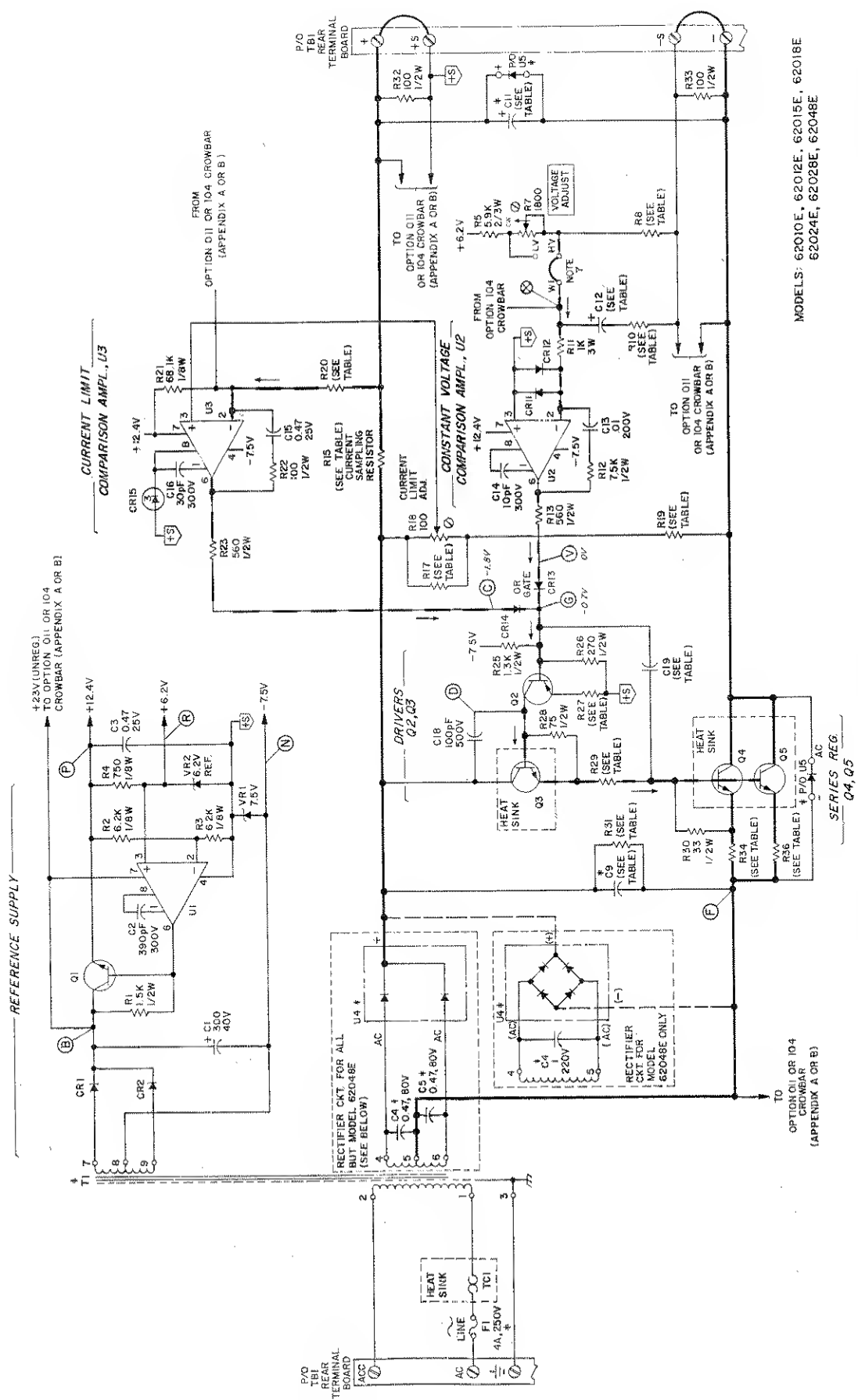


10. PIN LOCATIONS FOR TRANSISTORS ARE SHOWN BELOW:

11. PIN LOCATIONS FOR INTEGRATED CIRCUITS U1 THRU U4 ARE SHOWN BELOW:



MODELS 62010C, 62012C, 62015C ONLY
 (TOP VIEWS)

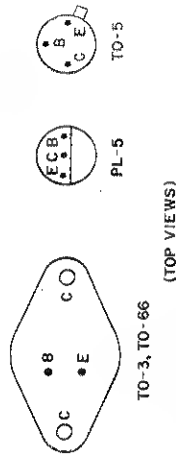


| MODEL | OUTPUT VOLTAGE (VDC) | OUTPUT (ADC @ 50°C) | TEST POINT (F) VOLTAGE | SCHEMATIC COMPONENTS | | | | | | | | | | | | | | | |
|--------|----------------------|---------------------|------------------------|----------------------|----------|----------|------------|----------|----------|----------|--------|--------|----------|----------|--------|--------|----------|--|--|
| | | | | C9 | C11 | C12 | C19 | R8 | R10 | R15 | R17 | R19 | R20 | R27 | R29 | R31 | R34, R36 | | |
| 62010E | 10±0.5 | 6.50 | -12V | 15000 30V | 8600 25V | 3.3 50V | | 10750 3W | 470 1/2W | 0.33 10W | 6.8 2W | 50 5W | 115 1/8W | 68 1/2W | 40 5W | 400 5W | 0.33 10W | | |
| 62012E | 12±0.6 | 6.00 | -24V | | | | | 12900 3W | | | | 3.9 2W | | 107 1/8W | | 50 5W | | | |
| 62015E | 15±0.75 | 5.00 | -28V | | | | | 16100 3W | | .05 10W | | 75 5W | 182 1/8W | | 75 5W | 600 5W | 0.5 5W | | |
| 62018E | 18±0.9 | 4.50 | -32V | | | | .0047 200V | 19350 3W | 1K 1/2W | | 2.7 2W | 135 5W | 162 1/8W | 10 1/2W | 135 5W | | | | |
| 62024E | 24±1.2 | 3.75 | -40V | 10000 50V | 3000 40V | 1 35V | | 25800 4W | | .07 5W | 3 3W | 200 5W | 139 1/8W | | 200 5W | 1K 5W | | | |
| 62028E | 28±1.4 | 3.25 | -45V | | | | | 30050 4W | | | 7.5 2W | 300 5W | 115 1/8W | | 300 5W | | 0.6 10W | | |
| 62048E | 48±2.4 | 2.00 | -72V | 5900 85V | 3000 85V | 0.47 80V | 0.022 200V | 51550 5W | 2K 1/2W | 0.125 5W | 5.6 2W | 750 5W | 110 1/8W | 12 1/2W | 680 5W | 3K 5W | 1 5W | | |

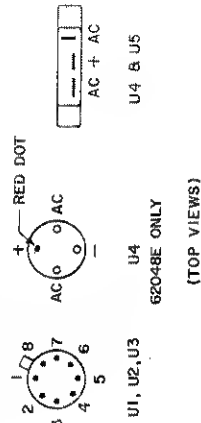
NOTES:

- ALL COMPONENTS ARE LOCATED ON P.C BOARD UNLESS OTHERWISE INDICATED
- † DENOTES CHASSIS MOUNTED COMPONENTS.
- DENOTES CONSTANT VOLTAGE FEEDBACK PATH.
- DENOTES CURRENT FEEDBACK PATH.
- ALL RESISTORS IN OHMS.
ALL 1/2W RESISTORS ±5%, UNLESS OTHERWISE INDICATED.
ALL 1/8W RESISTORS ±1%, UNLESS OTHERWISE INDICATED.
- ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE INDICATED.
- JUMPER W1 CONNECTED TO LV PAD FOR ALL LOW VOLTAGE (BELOW 10V) SUPPLIES AND TO HV FOR HIGHER VOLTAGE (10V AND ABOVE) SUPPLIES SEPARATE SCHEMATICS ARE SHOWN FOR EACH TYPE.
- TEST POINT VOLTAGES MEASURED UNDER THE FOLLOWING CONDITIONS:
 - HP MODEL 427A OR EQUIVALENT.
 - 115 VAC INPUT.
 - ALL VOLTAGES REFERENCED TO +S.
 - READINGS ARE TYPICAL ±10%.
 - ALL READINGS TAKEN IN CONSTANT VOLTAGE OPERATION.

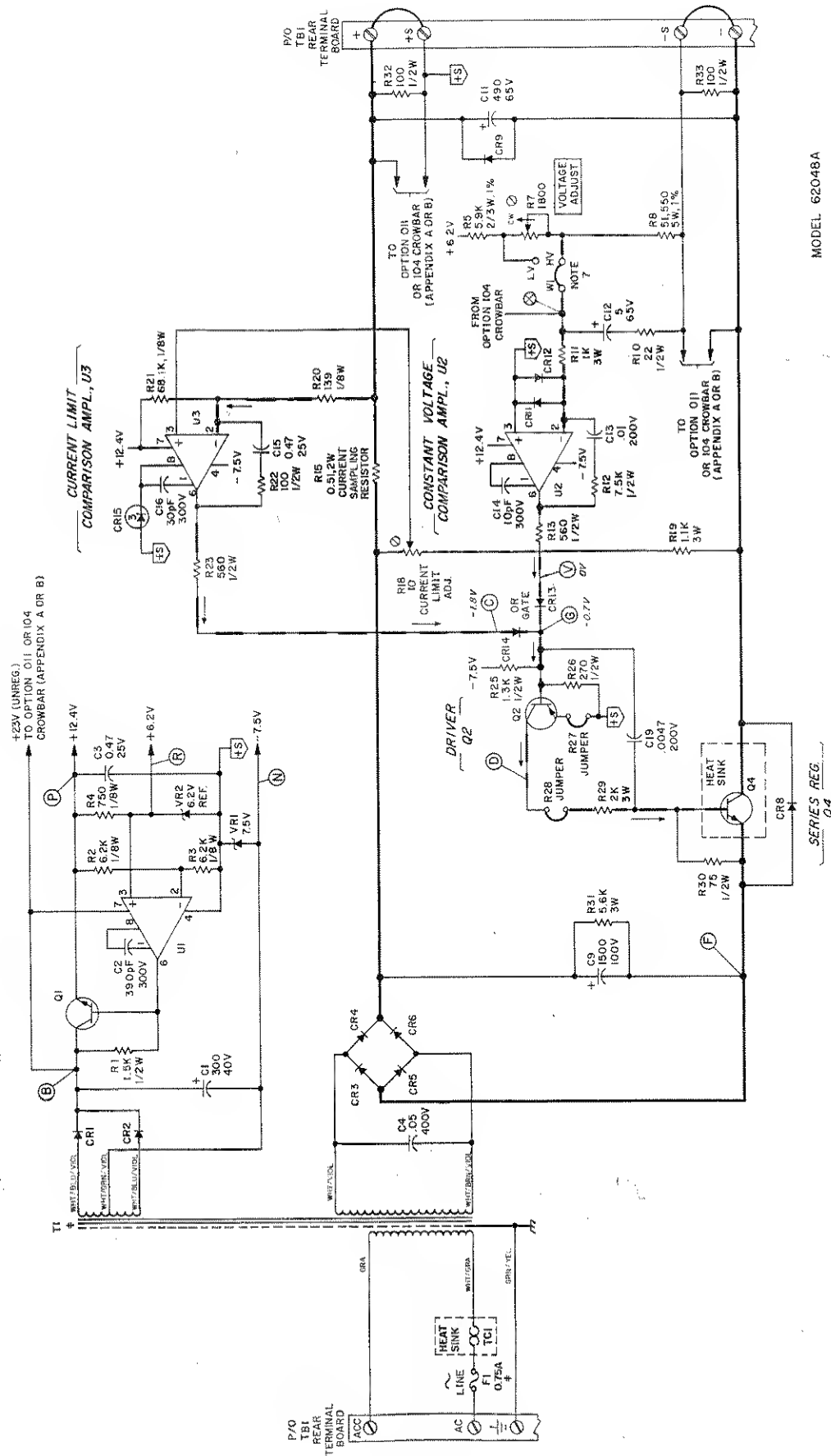
9. PIN LOCATIONS FOR TRANSISTORS ARE SHOWN BELOW



10. PIN LOCATIONS FOR INTEGRATED CIRCUITS U1 THRU U5 ARE SHOWN BELOW:



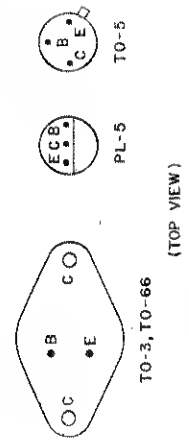
REFERENCE SUPPLY



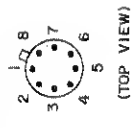
MODEL 62048A

SERIES REG. Q4

9. PIN LOCATIONS FOR TRANSISTORS ARE SHOWN BELOW:



10. PIN LOCATIONS FOR INTEGRATED CIRCUITS UI THRU U3 ARE SHOWN BELOW:



NOTES:

1. ALL COMPONENTS LOCATED ON P.C. BOARD, UNLESS OTHERWISE INDICATED.
2. * DENOTES CHASSIS MOUNTED COMPONENTS
3. --- DENOTES CONSTANT VOLTAGE FEEDBACK PATH.
4. --- DENOTES CURRENT FEEDBACK PATH.
5. ALL RESISTORS IN OHMS.
ALL 1/2W RESISTORS $\pm 5\%$, UNLESS OTHERWISE INDICATED.
ALL 1/8W RESISTORS $\pm 1\%$, UNLESS OTHERWISE INDICATED.
6. ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE INDICATED.
7. JUMPER W1 IS CONNECTED TO LV PAD FOR ALL LOW VOLTAGE (BELOW 10V) SUPPLIES AND TO HV FOR ALL HIGHER VOLTAGE (10V AND ABOVE) SUPPLIES. SEPARATE SCHEMATICS ARE SHOWN FOR EACH.
8. TEST POINT VOLTAGES MEASURED UNDER THE FOLLOWING CONDITIONS:
A. HP MODEL 427A OR EQUIVALENT
B. 115VAC INPUT.
C. ALL VOLTAGES REFERENCED TO +S.
D. READINGS ARE TYPICAL $\pm 10\%$.
E. ALL READINGS TAKEN IN CONSTANT VOLTAGE OPERATION

APPENDIX A

OPTION 011, Overvoltage Protection Crowbar

INTRODUCTION

This option is installed and tested at the factory and applies to the following Hewlett-Packard modular power supplies:

62003A through 62048A
62003C through 62048C
62003E through 62048E
62003G through 62048G

The Option 011 crowbar circuits for the above supplies are similar in design with many supplies utilizing identical crowbar circuits. Some variations in circuit operation and in component values do; however, exist so that two crowbar schematics are presented as part of this appendix. Also, all significant differences in circuit operation among the crowbar circuits are completely described.

In general, the crowbar circuits consist of components mounted on a separate printed wiring board. For the A- suffix models however, the trip level adjustment (R45) is mounted on the power supply main printed wiring board. For the G-suffix models, this resistor is mounted on the power supply main chassis.

CIRCUIT DESCRIPTION

The overvoltage protection crowbar circuit protects delicate loads from high voltage conditions that might result from a power supply failure such as a shorted series regulator. The crowbar circuit monitors the output of the power supply such that if the output exceeds an adjustable threshold, a virtual short circuit is placed across the output of the supply. The short circuit causes the output current to attempt to rise at which time the current limit comparison amplifier responds to reduce output voltage towards zero. Due to differences in voltage/current ratings among the modular power supplies, some employ a triac as the shorting element while others utilize an SCR. In addition, because of possible circuit delays in the low-voltage/high-current supplies as well as due to the high current dissipation requirements of some of the intermediate-voltage supplies, an alternate holding current path for the shorting element in these supplies is provided to prevent the supply from turning completely off during crowbar operation.

Figures A-1 and A-2 illustrate the two basic crowbar circuits provided for the 011 Option. As shown in the illustrations, the crowbar circuits are similar in design. Resistor R45, (CROWBAR ADJUST) adjusts the bias of Q1 with respect to -S and zener diode VR1 provides a stable reference

voltage which is compared with the -S potential. During normal operation, Q₁ is conducting and the next stage (Q2 or Q3) is cut-off. If the output voltage exceeds the voltage at which R45 is set, Q1 turns off which turns on the next stage to trigger the triac (CR5) or SCR (CR6) depending on the particular model. The triac or SCR thus places a short circuit across the output. The choice between using either the triac or SCR is merely a function of the current rating of the supplies with the higher current supplies employing the SCR circuit. Notice that all crowbar circuits employing the SCR require a pulse transformer (T1) which produces a positive trigger pulse to fire the SCR. The triac does not require a positive trigger pulse so the pulse transformer is not employed.

Notice that the higher current rated models (using either the triac or SCR) have a holding current path (through R9) returned to the negative side of C9 in the main power supply. This holding path keeps the SCR or triac conducting if the series regulator is turned off by the current limit circuit. For supplies with the highest current ratings (Figure A-2), transistor Q4 is included to immediately initiate turn-off when the crowbar fires. Turning down the supply in this manner, limits current dissipation in the crowbar circuit.

Temperature switch TS1 (Figure A-2 only) is provided to shut off the supply in the event of certain types of power supply failures where the current limit circuit cannot turn down the output and the line fuse does not blow. For example, if the series regulator became shorted, a turn-down signal from transistor Q4 would have no effect and the continuous current flow through the CR6 crowbar path could cause component damage. In this case, the current flow through the TS1 "heater" leads causes the device to open the positive lead in the main supply. Notice that once a temperature switch has been activated, it must be replaced as outlined on the next page. For those supplies with lower current ratings (Figure A-1), a temperature switch is not required because the line fuse will blow in the event of a series regulator short or any other failure where the supply cannot be turned-down automatically.

OPERATION

The crowbar can be set to trip anywhere in the range from +0.5Vdc above the minimum rated output voltage of the supply to +2V above the maximum rated output voltage. For example, the 62003A crowbar trip point can be set anywhere between 3.0Vdc to 5.5Vdc.

NOTE

To prevent transients from falsely tripping the crowbar, the trip voltage should be set higher than the power supply output by at least 0.75Vdc.

To set the crowbar trip voltage, perform the following procedures.

NOTE

Do not connect a load to the supply when setting the crowbar trip voltage.

1. Turn the CROWBAR ADJUST (screwdriver control) fully clockwise (trip voltage set at maximum).
2. Measure the power supply output voltage and set the output voltage (with the VOLTAGE ADJUST screwdriver control) for the desired crowbar trip voltage. If the desired trip voltage is beyond the maximum output voltage that can be attained by adjusting VOLTAGE ADJUST, perform the next step. If the supply can be set to the desired crowbar trip voltage, go on to step 4.
3. If the output of the supply cannot be set to the desired crowbar trip voltage:
 - a. Turn VOLTAGE ADJUST to minimum setting.
 - b. Turn off the supply and temporarily shunt a 12k, 5%, 1/2W resistor across resistor R5 on the main power supply board.
 - c. Turn on the supply and set power supply output to desired crowbar trip voltage.

CAUTION

Do not set output voltage more than 2V above the maximum output voltage rating of the supply.

4. Slowly turn the CROWBAR ADJUST counterclockwise until the crowbar trips (output falls towards 0 volt).
5. The crowbar remains activated and the output shorted until the supply is turned off. To reset the crowbar, turn the supply off. Before turning the supply back on, remove the shunt resistor installed in step 3 (if necessary) and turn VOLTAGE ADJUST to minimum. Turn the supply back on and set the power supply output voltage at least

0.75V below the crowbar trip voltage setting.

Resetting Crowbar

If the crowbar trips during normal operation (supply output goes to near zero), remove the input power to the supply and then disconnect any load from the power supply. Re-apply input power and determine if the crowbar again trips. If it does, there is a problem in the power supply. Check the line fuse and the temperature switch, TS1 (if provided) for open. If either of these devices are open, refer to the operating and service manual for troubleshooting procedures that can be used to isolate the cause of the overvoltage condition. If the supply does not crowbar when the load is removed, check the load circuit or the trip point setting.

Temperature Switch

A temperature switch, TS1, is included on some supplies (Figure A-2, Note 6) to shut down the unit in case of internal failures where the current through the SCR crowbar path could result in excessive dissipation. The power leads of the device will open if the current flow through the heater leads causes the temperature to reach $115 \pm 1.5^{\circ}\text{C}$. It takes between 4 to 40 seconds (depending mainly on the rating of the supply in question) after the SCR fires for the device to reach the activation temperature. Once a temperature switch has opened, it must be replaced as described in the next paragraph.

The temperature switch is polarity sensitive and its power leads must be connected as shown on Figure A-2, Note 6. The side with the ceramic insulator must be connected to the positive side of the rectifier (marked with a plated polarity dot on the P.C. board). The other power lead must be connected to current sampling resistor, R15. The heater leads are not polarity dependent and can be connected in any manner. When soldering in any of the temperature switch leads, apply heat to the leads for as short a period as possible as it requires only 115°C for the switch to open. The power leads are particularly susceptible to heat and the caution note below must be observed.

CAUTION

When soldering in the power leads of a temperature switch, connect an alligator clip to each lead to help dissipate heat. The switch will open at approximately 115°C , so solder the leads as quickly as possible.

Table A-1. Replaceable Parts Option 011 Crowbar (Models 62003A thru 62048A,
62006C thru 62048C; 62018E thru 62048E; 62018G thru 62048G)

| REF. DESIG. | DESCRIPTION | TO | MFR.PART NO. | MFR. CODE | HP PART NO. | RS |
|---|---|----|---------------|--------------|----------------|----|
| R45 62003A thru 62048A only | Main Power Supply Board Var. ww 1K, 5%, 1W (Crowbar Adjust) | 1 | Type CT-106-4 | 07716 | 2100-1758 | 1 |
| C1 | Option 011 Crowbar P.C. Board fxd, mylar .001 μ F 200Vdc | 1 | 192P10392 | 56289 | 0160-0153 | 1 |
| C2 | fxd, elect. 1 μ F 50Vdc | 1 | 30D105G0508A2 | 56289 | 0180-0108 | 1 |
| CR1 | Diode Si 250mW 200V | 1 | | 28480 | 1901-0033 | 1 |
| CR3 | | | | | | |
| 62003A, 62004A 62005A thru 62048A, 62006C thru 62048C, 62018E thru 62048E, 62018G thru 62048G | Diode Si 200V 3A | 1 | | 28480 | 1901-0416 | 1 |
| | Not Used (Jumper Installed) | | | | | |
| CR5 | Triac | 1 | | | 1884-0220 | 1 |
| Q1 | SS NPN Si | 1 | | 28480 | 1854-0071 | 1 |
| Q2 | SS NPN Si | 1 | | 28480 | 1854-0087 | 1 |
| R1 | fxd, ww 1.3K, 5%, 3W | 1 | 242E1325 | 56289 | 0811-1803 | 1 |
| R2 | | 1 | | | | 1 |
| 62003A | fxd, met. film 909, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0422 | |
| 62004A, 05A | fxd, met. film 1K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0280 | |
| 62006A, 6C | fxd, met. film 1.1K, 1%, 1/8W | | | 28480 | 0757-0424 | |
| 62010A, 10C | fxd, met. film 1.62K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0428 | |
| 62012A, 12C | fxd, met. film 1.78K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0278 | |
| 62015A, 15C | fxd, met. film 1.82K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0429 | |
| 62018A, 18C, 18E, 18G | fxd, met. film 1.96K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0698-0083 | |
| 62024A, 24C, 24E, 24G | fxd, met. film 2.15K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0698-0084 | |
| 62028A, 28C, 28E, 28G | fxd, met. film 2.21K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0430 | |
| 62048A, 48C, 48E, 48G | fxd, met. film 2.37K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0698-3150 | |
| R4 | | 1 | | | | 1 |
| 62003A | fxd, met. film 1.21K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0274 | |
| 62004A | fxd, met. film 1.62K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0428 | |
| 62005A | fxd, met. film 1.96K, 1%, 1/8W | | | 28480 | 0698-0083 | |
| 62006A, 6C | fxd, met. film 2.37K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0698-3150 | |
| 62010A, 10C | fxd, met. film 4.87K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0698-4444 | |
| 62012A, 12C | fxd, met. film 6.19K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0290 | |
| 62015A, 15C | fxd, met. film 7.5K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0440 | |
| 62018A, 18C, 18E, 18G | fxd, met. film 9.31K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0698-0064 | |
| 62024A, 24C, 24E, 24G | fxd, met. film 13.3K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0289 | |
| 62028A, 28C, 28E, 28G | fxd, met. film 16.2K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0447 | |
| 62048A, 48C, 48E, 48G | fxd, met. film 28.7K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0698-3449 | |
| R5 | fxd, met. film 2K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0283 | 1 |
| R6, 7 | fxd, comp 10K, 5%, 1/2W | 2 | EB-1035 | 01121 | 0686-1035 | 1 |
| R8 | fxd, comp 51, 5%, 1/2W | 1 | EB-5105 | 01121 | 0686-5105 | 1 |

Table A-1. Replaceable Parts (Continued)

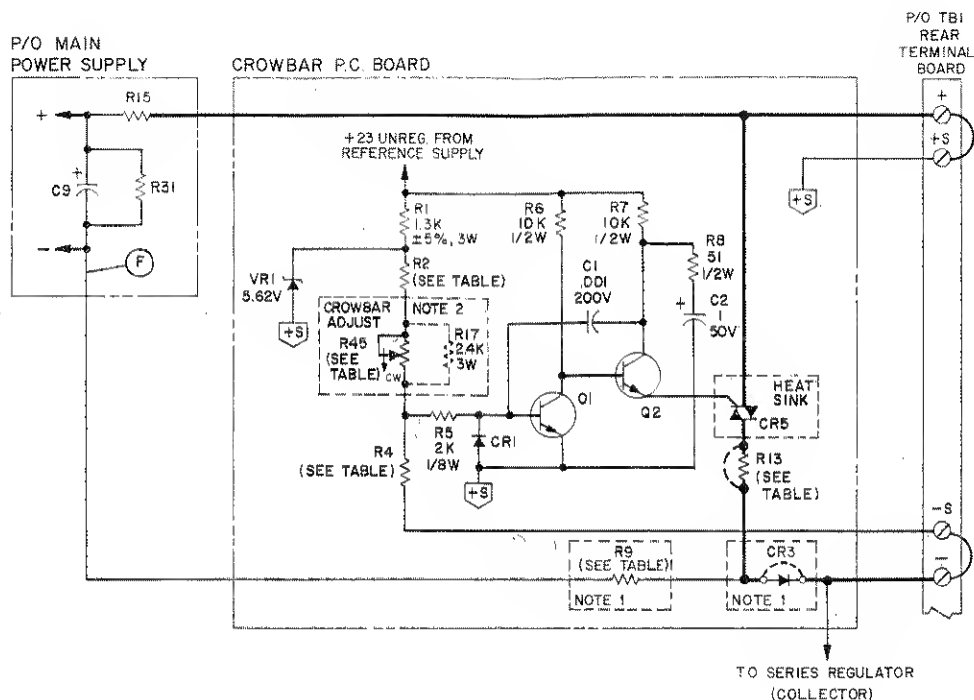
| REF. DESIG. | DESCRIPTION | TQ | MFR.PART NO. | MFR. CODE | HP PART NO. | RS |
|---|-----------------------------|----|---------------|--------------|----------------|----|
| R9 | | | | | | |
| 62003A | fxd, ww 100, 5%, 3W | 1 | Type 242E1015 | 56289 | 0813-0050 | 1 |
| 62004A | fxd, ww 135, 5%, 3W | 1 | Type 242E | 56289 | 0812-0112 | 1 |
| 62005A thru 62048A, 62006C thru 62048C, 62018E thru 62048E, 62018G thru 62048G | Not Used | 1 | | | | 1 |
| R13 | | | | | | |
| 62003A thru 62006A | fxd, ww 0.125, 10%, 3W | | Type CW2B-1 | 91637 | 0811-1828 | |
| 62010A thru 62018A | fxd, ww 0.25, 10%, 3W | | Type CW2B-1 | 91637 | 0811-1829 | |
| 62024A, 62028A | fxd, ww 0.5, 10%, 3W | | Type CW2B-1 | 91637 | 0811-1830 | |
| 62048A | fxd, ww 1.0, 5%, 3W | | Type 242E1R05 | 56289 | 0811-1732 | |
| 62006C | Not Used (Jumper Installed) | | | | | |
| 62010C | fxd, ww 0.25, 10%, 3W | | Type CW2B-1 | 91637 | 0811-1829 | |
| 62012C thru 62018C, 62024E, 62024G | fxd, ww 0.25, 10%, 5W | | Type CW5-2 | 91637 | 0811-1847 | |
| 62024C, 62028C, 62028E, 62028G | fxd, ww 0.5, 5W | | Type CW5-2 | 91637 | 0811-1848 | |
| 62048C, 62048E | fxd, ww 1, 10%, 5W | | Type 243E1R05 | 56289 | 0811-1340 | |
| 62018E | fxd, ww 0.125, 10%, 5W | | K46509 | 21740 | 0811-1846 | |
| 62018G | fxd, ww 0.07, 5%, 5W | | RS-5-78 | 68601 | 0811-3174 | |
| 62048G | fxd, ww 0.5, 10%, 5W | | CW5-2 | 91637 | 0811-1848 | |
| R17 | | 1 | | | | 1 |
| 62003A thru 62048A, 62006C thru 62048C, 62018E thru 62048E | Not Used | | | | | |
| 62018G thru 62048G | fxd, ww 2.4K, 5%, 3W | 1 | | | 0811-1807 | 1 |
| R45 | | | | | | |
| (See Main Supply for A-Series) | | | | | | |
| 62006C thru 62048C, 62010E thru 62048E | Var. ww 1K, 5%, 1W | | Type CT-106-4 | 07716 | 2100-1758 | |
| 62010G thru 62048G | Var. ww 1800, 5%, 1W | | | 28480 | 2100-3254 | |
| VR1 | Diode, zener, 5.62V, 400mW | 1 | | 28480 | 1902-3104 | |

Table A-2. Replaceable Parts Option 011 Crowbar (Models 62003C thru 62005C;
62003E thru 62015E; 62003G thru 62015G)

| REF. DESIG. | DESCRIPTION | TQ | MFR.PART NO. | MFR. CODE | HP PART NO. | RS |
|---|---|----|---------------|--------------|----------------|----|
| C1 | Option 011 Crowbar P.C. Board fxd, mylar .001 μ F 200Vdc | 1 | 192P10392 | 56289 | 0160-0153 | 1 |
| C2 | fxd, elect. 1 μ F 50Vdc | 1 | 30D105G050BA2 | 56289 | 0180-0108 | 1 |
| C3 | fxd, mylar .022 μ F 200V | 1 | 292P22392-PTS | 56289 | 0160-0162 | 1 |
| CR1, CR2 | Diode Si 250mW 200V | 3 | | 28480 | 1901-0033 | 3 |
| CR3 | | | | | | |
| 62003C, 62004C 62003E thru 62005E, 62003G thru 62006G 62005C, 62006E, 62010G thru 62015G | Diode Si 12A; 100V | 1 | 1N1200A | 02735 | 1901-0002 | 1 |
| CR4 | Not Used (Jumper Installed) Diode Si 250mW 200V | | | 28480 | 1901-0033 | |
| CR6 | SCR | 1 | 2N3669 | 02735 | 1884-0019 | 1 |
| Q1 | SS NPN Si | 1 | | 28480 | 1854-0071 | 1 |
| Q3 | SS NPN Si | 1 | | 28480 | 1854-0087 | 1 |
| Q4 | | | | | | |
| 62003C, 62004C, 62003E thru 62005E, 62003G thru 62006G 62005C, 62006E, 62010G thru 62015G | SS NPN Si | 1 | | 24480 | 1854-0071 | 1 |
| R1 | Not Used | | | | | |
| R2 | fxd, ww 1.3K, 5%, 3W | 1 | 242E1325 | 56289 | 0811-1803 | 1 |
| 62003C, 62003E, 62003G | | 1 | | | | 1 |
| 62004C, 5C, 62004E, 5E, 62004G, 5G | fxd, met. film 909, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0422 | |
| 62006E, 6G | fxd, met. film 1K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0280 | |
| 62010E, 10G | fxd, met. film 1.1K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0424 | |
| 62012E, 12G | fxd, met. film 1.62K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0428 | |
| 62015E, 15G | fxd, met. film 1.78K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0278 | |
| R4 | fxd, met. film 1.82K, 1%, 1/8W | 1 | Type CEA T-0 | 07716 | 0757-0429 | 1 |
| 62003C, 3E, 3G | fxd, met. film 1.21K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0274 | |
| 62004C, 4E, 4G | fxd, met. film 1.62K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0428 | |
| 62005C, 5E, 5G | fxd, met. film 1.96K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0698-0083 | |
| 62006E, 6G | fxd, met. film 2.37K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0698-3150 | |
| 62010E, 10G | fxd, met. film 4.87K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0698-4444 | |
| 62012E, 12G | fxd, met. film 6.19K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0290 | |
| 62015E, 15G | fxd, met. film 7.5K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0440 | |
| R5 | fxd, met. film 2K, 1%, 1/8W | | Type CEA T-0 | 07716 | 0757-0283 | 1 |
| R6, 7 | fxd, comp 10K, 5%, 1/2W | 2 | EB-1035 | 01121 | 0686-1035 | 1 |
| R8 | fxd, comp 51, 5%, 1/2W | 1 | EB-5105 | 01121 | 0686-5105 | 1 |

Table A-2. Replaceable Parts (Continued)

| REF. DESIG. | DESCRIPTION | TQ | MFR.PART NO. | MFR. CODE | HP PART NO. | RS |
|---------------------|-----------------------------|----|---------------|-----------|-------------|----|
| R9 | | | | | | |
| 62003C, 3E, 3G | fxd, ww 50, 5%, 5W | 1 | Type 243E5005 | 56289 | 0811-1854 | 1 |
| 62004C, 4E, 4G | fxd, ww 75, 5%, 5W | 1 | Type 243E7505 | 56289 | 0812-0097 | 1 |
| 62005C | Not Used | | | | | |
| 62005E, 5G | fxd, ww 100, 3%, 5W | 1 | Type 243E1015 | 56289 | 0812-0018 | 1 |
| 62006E | Not Used | | | | | |
| 62006G | fxd, ww 135, 3%, 5W | 1 | | | | |
| 62010E thru 62015E, | | | | | | |
| 62010G thru 62015G | Not Used | 1 | | | | 1 |
| R10 | | | | | | |
| 62003C, 3E, 4G, 5E | fxd, comp 510, 5%, ½W | | EB-5115 | 01121 | 0686-5115 | |
| 62003G | fxd, comp 270, 5%, ½W | | EB-2715 | 01121 | 0686-2715 | |
| 62004C, 4E | fxd, comp 750, 5%, ½W | | EB-7515 | 01121 | 0686-7515 | |
| 62005C, 6E | Not Used | | | | | |
| 62005G | fxd, comp 630, 5%, ½W | | EB-6815 | 01121 | 0686-6815 | |
| 62006G | fxd, comp 1K, 5%, ½W | | EB-1025 | 01121 | 0686-1025 | |
| 62010E thru 62015E, | | | | | | |
| 62010G thru 62015G | Not Used | 1 | EB-1005 | 01121 | 0686-1005 | 1 |
| R12 | fxd, comp 10, 5%, ½W | | | | | |
| R17 | | | | | | |
| 62003C thru 62005C, | | | | | | |
| 62003E thru 62006E | Not Used | 1 | | | 0811-1807 | 1 |
| 62003G thru 62015G | fxd, ww 2.4K, 5%, 3W | 1 | | | | 1 |
| R18 | | | | | | |
| 62003C thru 62005C, | | | | | | |
| 62003E thru 62006E, | | | | | | |
| 62003G thru 62006G | Not Used (Jumper Installed) | | | | | |
| 62010E thru 62015E, | | | | | 0811-3222 | |
| 62010G thru 62015G | fxd, ww 0.18, 5%, 10W | 1 | | | | 1 |
| R19 | | | | | | |
| 62003C thru 62005C | Not Used | | | | | |
| 62003E thru 62006E | fxd, ww 0.33, 5%, 10W | | RS-10-46 | 68601 | 0811-3177 | |
| 62010E thru 62015E | fxd, ww 0.25, 5%, 10W | | RS-10-46 | 68601 | 0811-3716 | |
| 62003G, 62010G | | | | | | |
| thru 62015G | fxd, ww 0.18, 5%, 10W | | RS-10-46 | 68601 | 0811-3222 | |
| 62004G thru 62006G | fxd, ww 0.07, 5%, 5W | 1 | RS-5-78 | 68601 | 0811-3174 | 1 |
| R45 | | | | | | |
| 62003C thru 62005C, | | | Type CT-106-4 | 07716 | 2100-1758 | |
| 62003E thru 62015E | Var. ww 1K, 5%, 1W | | | 28480 | 2100-3254 | |
| 62003G thru 62015G | Var. ww 1800, 5%, 1W | | | 28480 | 9100-2160 | 1 |
| T1 | Pulse Transformer | 1 | | 28480 | 1902-3104 | 1 |
| VR1 | Diode, zener 5.62V 400mW | 1 | | 27012 | 2110-0471 | 3 |
| TS1 | Temperature Switch | 1 | 923917 | | | |

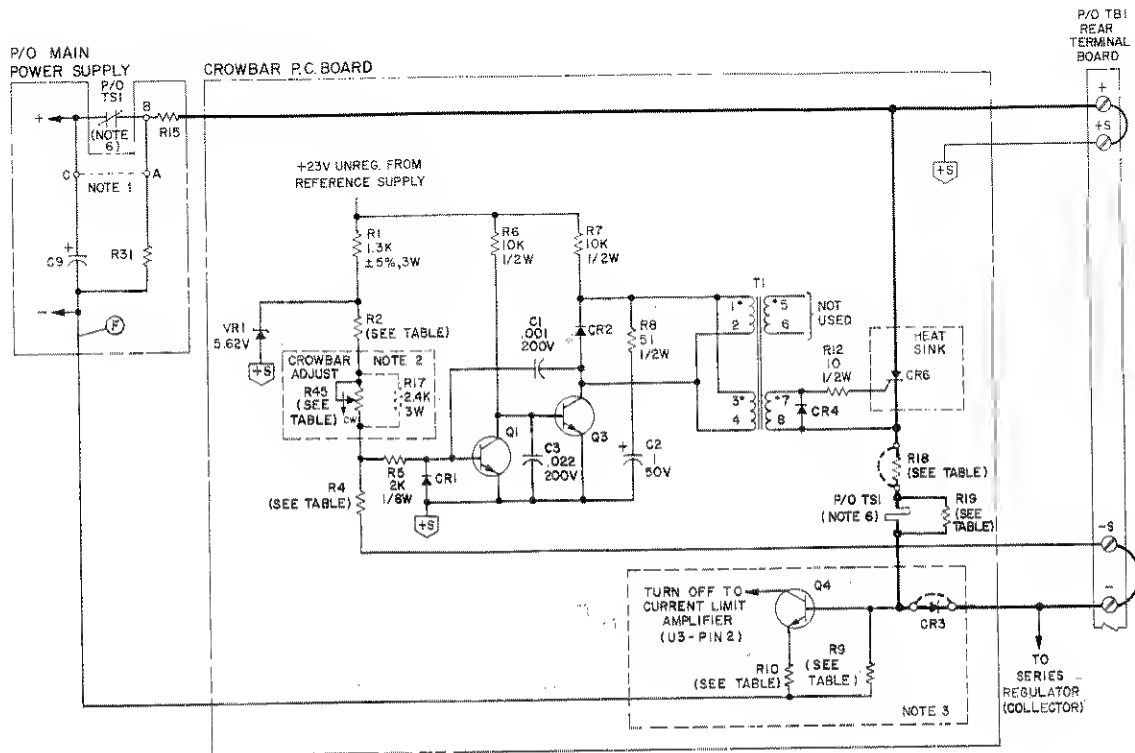


| COMPONENT | VALUE(S) FOR MODEL(S) (IN OHMS) | | | | | | | | | | |
|-----------|---------------------------------|---------------|---------------|-----------------------------|------------------|----------------------------------|----------------------------------|---|--|--|--|
| | 62003A | 62004A | 62005A | 62006A 62006C | 62010A 62010C | 62012A 62012C | 62015A 62015C | 62018A 62018C 62018E 62018G | 62024A 62024C 62024E 62024G | 62028A 62028C 62028E 62028G | 62048A 62048C 62048E 62048G |
| R2 | 909 1/8W | 1K 1/8W | 1K 1/8W | 1.1K 1/8W | 1.62K 1/8W | 1.78K 1/8W | 1.82K 1/8W | 1.96K 1/8W | 2.15K 1/8W | 2.21K 1/8W | 2.37K 1/8W |
| R4 | 1.21K 1/8W | 1.62K 1/8W | 1.96K 1/8W | 2.37K 1/8W | 4.87K 1/8W | 6.19K 1/8W | 7.5K 1/8W | 9.31K 1/8W | 13.3K 1/8W | 16.2K 1/8W | 28.7K 1/8W |
| R9 | 100 3W | 135 3W | — | — | — | — | — | — | — | — | — |
| R13 | 0.125 3W | 0.125 3W | 0.125 3W | 6A-0.125 3W 6C-JUMPER | 0.25 3W | 12A-0.25 3W 12C-0.25 5W | 15A-0.25 3W 15C-0.25 5W | 18A-0.25,3W 18C-0.25,5W 18E-0.125,5W 18G-0.07,5W | 24A-0.5,3W 24C-0.5,5W 24E-0.25 24G-5W | 28A-0.5,3W 28C-0.5 28E-0.5W | 48A-1,3W 48C-1,5W 48E-0.5,5W |
| R45 | 1K | 1K | 1K | 1K | 1K | 1K | 1K | 18A-1K 18C-1K 18E-1.8K 18G-1.8K | 24A-1K 24C-1K 24E-1.8K 24G-1.8K | 28A-1K 28C-1K 28E-1.8K 28G-1.8K | 48A-1K 48C-1K 48E-1.8K 48G-1.8K |

NOTES:

1. CR3 AND R9 PROVIDED FOR 62003A AND 62004A ONLY. CR3 DELETED (JUMPER INSTALLED) AND R9 DELETED FOR ALL OTHER MODELS (NO CONNECTION FROM CROWBAR BOARD TO NEGATIVE SIDE OF C9).
2. R17 PROVIDED FOR 62018G THROUGH 62048G SUPPLIES ONLY. ALSO, FOR THESE SUPPLIES, R45 MOUNTED ON CHASSIS. FOR ENTIRE "A" SUFFIX SERIES, R45 MOUNTED ON MAIN POWER SUPPLY PRINTED WIRING BOARD. FOR OTHER ("C" AND "E" SUFFIX) SUPPLIES, R45 MOUNTED ON CROWBAR PRINTED WIRING BOARD.
3. ALL RESISTORS IN OHMS, 1/2W RESISTORS $\pm 5\%$, ALL 1/8W RESISTORS $\pm 1\%$, UNLESS OTHERWISE INDICATED.
4. ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE INDICATED.

Figure A-1. Option 011 Crowbar Schematic, Models 62003A thru 62048A, 62006C thru 62048C, 62018E thru 62048E, and 62018G thru 62048G.



| COMPONENT | VALUE(S) PER MODEL(S) IN OHMS | | | | | | | |
|-----------|---|--|---|---------------------------|------------------------------|------------------------------|------------------------------|--|
| | 62003C 62003E 62003G | 62004C 62004E 62004G | 62005C 62005E 62005G | 62006E 62006G | 62010E 62010G | 62012E 62012G | 62015E 62015G | |
| R2 | 909 1/8W | 1K 1/8W | 1K 1/8W | 1.1K 1/8W | 1.62K 1/8W | 1.78K 1/8W | 1.82K 1/8W | |
| R4 | 1.21K 1/8W | 1.62K 1/8W | 1.96K 1/8W | 2.37K 1/8W | 4.87K 1/8W | 6.19K 1/8W | 7.5K 1/8W | |
| R9 | 50 5W | 75 5W | 5C-NOT USED 5E-100,5W 5G- | 6E-NOT USED 6G-135,5W | --- | --- | --- | |
| R10 | 3C-510,1/2W 3E- 3G-270,1/2W | 4C-750,1/2W 4E- 4G-510,1/2W | 5C-NOT USED 5E-750,1/2W 5G-680,1/2W | 6E-NOT USED 6G-1K,1/2W | --- | --- | --- | |
| R18 | JUMPER | JUMPER | JUMPER | JUMPER | 0.18 10W | 0.18 10W | 0.18 10W | |
| R19 | 3C-NOT USED 3E-0.33,10W 3G-0.18,10W | 4C-NOT USED 4E-0.33,10W 4G-0.07,5W | 5C-0.18,10W 5E-0.33,10W 5G-0.07,5W | 6E-0.33,10W 6G-0.07,5W | 10E-0.25,10W 10G-0.18,10W | 12E-0.25,10W 12G-0.18,10W | 15E-0.25,10W 15G-0.18,10W | |
| R45 | 3C-1K 3E- 3G-1.8K | 4C-1K 4E- 4G-1.8K | 5C-1K 5E-1.8K 5G-1.8K | 6E-1K 6G-1.8K | 10E-1K 10G-1.8K | 12E-1K 12G-1.8K | 15E-1K | |

- NOTES:
1. POINT A WIRED TO B FOR 62003C THRU 62005C AND 62003E THRU 62015E SUPPLIES. FOR 62003G THRU 62015G SUPPLIES, POINT A IS CONNECTED TO POINT C.
 2. R17 PROVIDED FOR 62003G THRU 62015G SUPPLIES ONLY. ALSO FOR THESE SUPPLIES, R45 MOUNTED ON CHASSIS. FOR OTHER ("C" AND "E" SUFFIX) SUPPLIES, R45 MOUNTED ON CROWBAR PRINTED WIRING BOARD.
 3. CR3, Q4, R9 AND R10 PROVIDED FOR THE 62003C, 62004C, 62003E THRU 62005E AND 62003G THRU 62006G MODELS ONLY. FOR ALL OTHER MODELS (62005C, 62006E AND 62010G THRU 62015G), A JUMPER IS INSTALLED IN PLACE OF CR3 AND THE OTHER COMPONENTS REMOVED (NO CONNECTION FROM CROWBAR TO NEGATIVE SIDE OF C9).
 4. ALL RESISTORS IN OHMS, 1/2W RESISTORS $\pm 5\%$, ALL 1/8W RESISTORS $\pm 1\%$, UNLESS OTHERWISE INDICATED.
 5. ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE INDICATED.
 6. TEMPERATURE SWITCH TSI IS SHOWN BELOW. THE POWER LEADS MUST BE CONNECTED AS SHOWN. READ DESCRIPTION AND REPLACEMENT PROCEDURES ON PAGE A-2.

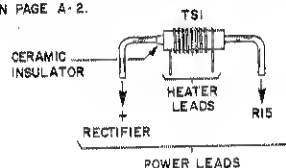


Figure A-2. Option 011 Crowbar Schematic, Models 62003C thru 62005C, 62003E thru 62015E, and 62003G thru 62015G.